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STANDARD SPECIFICATIONS

For

ROAD AND BRIDGE CONSTRUCTION

PLEASE RETURN

1976 Edition

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**Montana Department of Highways
and the
Montana Highway Commission**

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STANDARD SPECIFICATIONS

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Helena, Montana 59601

METRICATION

Metrication equivalents have not been incorporated in this edition. However, the following is a list of widely applicable conversion factors which are officially approved for use when it is necessary to convert any quantities or dimensions from the English System to the Metric System.

<u>To convert from</u>	<u>To</u>	<u>Multiply by</u>
inch	meter (m)	$2.540\ 000 \div 10^2$
foot	meter (m)	$3.048\ 000 \div 10$
foot ²	meter ² (m ²)	$9.290\ 304 \div 10^2$
yard ²	meter ² (m ²)	$8.361\ 274 \div 10$
foot ³	meter ³ (m ³)	$2.831\ 685 \div 10^2$
yard ³	meter ³ (m ³)	$7.645\ 549 \div 10$
pound-mass (1bm avoird.)	kilogram (kg)	$4.535\ 924 \div 10$
gallon (U.S. liquid)	meter ³ (m ³)	$3.785\ 412 \div 10^3$
pound-force/inch ² (psi)	newton/meter ² (N/m ²)	$6.894\ 757 \times 10^3$
pound-mass/foot ³	kilogram/meter ³ (kg/m ³)	$1.601\ 846 \times 10$
degree Fahrenheit	degree Celsius	$tc = (tf - 32) / 1.8$

NOTATION:

Conversion factors are presented for ready adaptation to computer readout and electronic data transmission. The factors are written as a number greater than one and less than ten with six or less decimal places. Sometimes this number is followed by the letter E (for exponent), a plus or minus symbol, and two digits which indicate the power of 10 by which the number must be multiplied to obtain the correct value. For example,

3.523 907 E-02 is $3.523\ 907 \times 10^{-2}$ or 0.035 239 07.

Similarly,

3.386 389 E + 03 is 3.386×10^3 or 3 386.389.

STANDARD SPECIFICATIONS

Tables of Contents

		Titles	Page
Section	1	Definitions and Terms	1
Section	2	Bidding Requirement and Conditions.....	11
Section	3	Award and Execution of Contract.....	21
Section	4	Scope of Work.....	23
Section	5	Control of the Work.....	33
Section	6	Control of Material.....	41
Section	7	Legal Relations and Responsibility to the Public.....	51
Section	8	Prosecution and Progress.....	65
Section	9	Measurement and Payment.....	77
Section	10	Clearance of Right-of-Way	91
Subsection	10.00	Clearing and Grubbing	91
Subsection	10.30	Removal of Structures and Obstructions	98
Section	11	Excavation and Embankment.....	103
Section	12	Haul	123
Subsection	12.10	Haul	123
Subsection	12.20	Aggregate Haul	124
Section	13	Rolling and Watering	125
Subsection	13.10	Rolling.....	125
Subsection	13.50	Watering	128
Section	14	Unassigned	
Section	15	Unassigned	
Section	16	Contingent Construction and Operations	135
Subsection	16.00	Equipment Use.....	135
Subsection	16.10	Road Leveler Operations	137
Subsection	16.40	Obliterate Roadway	138
Section	17	Roadside Development.....	141
Subsection	17.00	Topsoiling	141
Subsection	17.10	Seeding and Fertilizing.....	142
Subsection	17.20	Mulching.....	149
Subsection	17.30	Sodding	153

	Titles	Page
Subsection 17.40	Soil Retention Blankets.....	156
Section 18	Lime Treated Roadbed	159
Section 19	Roadbed Modification and Surface Preparation	163
Subsection 19.10	Roadbed Modification	163
Subsection 19.20	Existing Surface Preparation	165
Section 20	Aggregate Surfacing	169
Section 21	Various Surfacing Types	179
Subsection 21.00	Selected Surfacing.....	179
Subsection 21.50	Sand Surfacing.....	179
Section 22	Portland Cement Treated Base	181
Section 23	Unassigned	
Section 24	Unassigned	
Section 25	Crushed Cover Aggregate	191
Section 26	Stockpiled Surfacing Aggregate	193
Section 27	Unassigned	
Section 28	Unassigned	
Section 29	Unassigned	
Section 30	Plant Mix Pavement	195
Subsection 30.20	Plant Mix Bituminous Base Course	218
Section 31	Bituminous Prime or Tack Coat	223
Section 32	Bituminous Surface Treatment.....	227
Section 33	Road Mix Bituminous Pavement	235
Section 34	Seal Coat.....	243
Section 35	Unassigned	
Section 36	Unassigned	
Section 37	Unassigned	
Section 38	Unassigned	
Section 39	Portland Cement Concrete Pavement	249
Section 40	Portland Cement Concrete	277
Section 41	Concrete Structures	297
Subsection 41.10	Protective Coating for Concrete Bridge Superstructures	316
Section 42	Prestressed Concrete Members	319
Section 43	Steel Structures.....	341
Section 44	Timber Structures.....	363
Section 45	Structure Excavation	369
Section 46	Piling	375

		Titles	Page
Section	47	Reinforcing Steel.....	389
Section	48	Steel Bridge Railing.....	393
Section	49	Miscellaneous Structure Items	395
Section	50	Slope and Bank Protection	397
Subsection	50.10	RipRap	397
Subsection	50.20	Rubble Masonry.....	401
Subsection	50.30	Bank Protection	403
Subsection	50.40	Concrete Slope Protection	405
Section	51	Retaining Walls.....	407
Section	52	Excavation for Culverts and Minor Structures	411
Section	53	Unassigned	
Section	54	Installation of Pipe Culverts	415
Section	55	Remove and Relay Pipe Culverts	423
Section	56	Corrugated Steel Pipe Culverts.....	425
Section	57	Corrugated Steel Pipe Arch Culverts	427
Section	58	Unassigned	
Section	59	Steel Structural Plate Pipe, Structural Plate Pipe Arch Culverts and Stockpasses.....	429
Section	60	Unassigned	
Section	61	Unassigned	
Section	62	Reinforced Concrete Pipe Culverts.....	431
Section	63	Reinforced Concrete Arches and Underpasses	435
Section	64	Unassigned	
Section	65	Corrugated Aluminum Pipe and Pipe Arch Culverts	435
Section	66	Unassigned	
Section	67	Unassigned	
Section	68	Unassigned	
Section	69	Pipe Underdrains	437
Section	70	Unassigned	
Section	71	Unassigned	
Section	72	Unassigned	
Section	73	Irrigation Facilities and Headwalls	439
Section	74	Cast Iron Pipe and Culverts	443
Section	75	Curbs and Gutters	445

	Titles	Page
Section 76	Concrete Sidewalks	449
Section 77	Manholes, Inlets, Catch Basins, Covers, Risers, Etc.	451
Section 78	Pipe and Tubing	453
Section 79	Unassigned	
Section 80	Chain Link Fence	455
Section 81	Fence	461
Section 82	Cattle Guards	469
Section 83	Unassigned	
Section 84	Unassigned	
Section 85	Conduits, Ducts and Pull Boxes	471
Section 86	Unassigned	
Section 87	Traffic Signals and Lighting.....	477
Section 88	Signs and Signing.....	487
Section 89	Pavement Markings and Markers	491
Section 90	Traffic Guidance Devices.....	497
Subsection 90.00	Guard Rail and Median Barrier Rail	497
Subsection 90.40	Guide Posts	499
Section 91	Paints and Painting	501
Section 92	Remove, Reset and Adjust Facilities.....	509
Section 93	Unassigned	
Section 94	Unassigned	
Section 95	Unassigned	
Section 96	Markers and Monuments	511
Section 97	Non-Participating Items	513

MATERIALS

M-100	Aggregates	515
M-110	Unassigned	
M-120	Bituminous Materials	527
M-130	Unassigned	
M-140	Unassigned	
M-150	Joint Materials.....	541
M-160	Concrete, Clay, Plastic and Fiber Pipe.....	545
M-170	Metal Pipe	549

	Titles	Page
M-180	Unassigned	
M-190	Unassigned	
M-200	Unassigned	
M-210	Fencing Materials	555
M-220	Guard Rail and Guide Posts	565
M-230	Unassigned	
M-240	Unassigned	
M-250	Unassigned	
M-260	Unassigned	
M-270	Treated and Untreated Timber	569
M-280	Paints.....	571
M-290	Reinforcing Steel, Structural Steel Hardware and Miscellaneous Structure Items	581
M-300	Unassigned	
M-310	Lighting and Signal Materials.....	585
M-320	Signing Materials.....	639
M-330	Unassigned	
M-340	Miscellaneous Materials.....	661

SECTION 1

DEFINITIONS AND TERMS

Whenever, in these specifications or in other contract documents, the following terms, or pronouns in place of them, are used, the intent and meaning shall be interpreted as follows:

A vertical line on the border of the page signifies additions or revisions to previous specifications.

It shall be understood, that as a general rule - specifications in existence on the first day of advertising for bids shall be the governing specifications through-out the contract life of a project without making specific specification reference by date.

01.01 ABBREVIATIONS. Whenever the following abbreviations are used in these specifications, or plans, or any contractual instruments, they are to be construed the same as the respective expressions represented:

AAN - American Association of Nurserymen

AAR - Association of American Railroads

AASHTO - American Association of State Highways and Transportation Officials

AGC - Associated General Contractors of America

AIA - American Institute of Architects

AISI - American Iron and Steel Institute

ANSI - American National Standards Institute, Inc.

ARA - American Railway Association

AREA - American Railway Engineering Association

ASCE - American Society of Civil Engineers

ASLA - American Society of Landscape Architects

ASME - American Society of Mechanical Engineers

ASTM - American Society for Testing and Materials

AWPA - American Wood Preservers Association

AWWA - American Water Works Association

AWS - American Welding Society

FHWA - The Federal Highway Administration

FSS - Federal Specifications and Standards

GSA - General Services Administration

MDOH - The Montana Department of Highways

MUTCD - Manual on Uniform Traffic Control Devices

NBS - National Bureau of Standards

OSHA - Occupational Safety and Health Act of 1970

SAE - Society of Automotive Engineers

SSPC - Steel Structures Painting Council

UL - Underwriters Laboratory

WASHTO - Western Association of State Highway Transportation Officials

01.02 ADDITIONAL WORK. Additional work is an increase in the quantity of a contract item.

01.03 ADVERTISEMENT. The public announcement, as required by law, inviting bids for work to be performed or materials to be furnished.

01.04 AWARD. The acceptance of a bid by the Commission.

01.05 BASE. The layer or layers of specified material of designed thickness placed on the sub-base or subgrade to support the pavement or surface course.

01.06 BIDDER. An individual, firm, partnership, joint venture or corporation submitting a bid for the advertised work.

01.07 BRIDGE. A structure, including supports, erected over a depression or an obstruction, as water, highway, or railway, and having a track or passageway for carrying traffic or other moving loads and having a length measured along the center of roadway of more than 20 feet between undercopings of abutments or extreme ends of openings for multiple boxes or culverts.

Length. The length of the bridge structure is the over-all length measured along the line of survey stationing back to back of back-walls of abutments, if present, otherwise end to end of the bridge floor; but in no case less than the total clear opening of the structure.

Roadway width. The clear width measured at right angles to the longitudinal centerline of the bridge between the bottom of curbs or guard timbers or in the case of multiple height of curbs, between the bottoms of the lower risers.

01.08 CALENDAR DATE OF COMPLETION. Fixed calendar date on which all work on the project, shall be satisfactorily completed.

01.09 CALENDAR DAY. Every day shown on the calendar beginning and ending at midnight.

01.10 CHANGE ORDER. A written order issued by the engineer to the contractor, covering changes in the plans or quantities or both, within the scope of the contract and establishing the basis of payment and time adjustments for the work affected by the changes.

01.11 CONTRACT. The written agreement between the State Highway Commission and the contractor setting forth the obligations of the parties thereunder, including, but not limited to, the performance of the work, the furnishing of labor and materials, and the basis of payment.

The contract includes the instruction to bidders, proposal, contract form and contract bond, specifications, supplemental specifications, special provisions, general and detail plans, standard drawings, and notice to proceed, also all change orders and agreements that are required to complete the construction of the work in an acceptable manner, including authorized extensions thereof, all of which constitute one instrument.

01.12 CONTRACT BOND. The approval form of security, executed by the contractor and his surety or sureties, guaranteeing complete execution of the contract and all supplemental agreements pertaining thereto and the payment of all legal debts pertaining to the construction of the project.

01.13 CONTRACT ITEM (Pay Item). A specifically described unit of work for which a price is provided in the contract.

01.14 CONTRACT PAYMENT BOND. The security furnished by the contractor and his surety to guarantee payment of the debts covered by the bond.

01.15 CONTRACT PERFORMANCE BOND. The security furnished by the contractor and his surety to guarantee performance of the work in accordance with the contract.

01.16 CONTRACT TIME. The number of work days or calendar days allowed for completion of the contract, including authorized time extensions.

01.17 CONTRACTOR. The individual, partnership, joint-venture, firm or corporation contracting with the Montana State Highway Commission for performance of prescribed work.

01.18 CULVERT. Any structure not classified as a bridge which provides an opening under the roadway.

01.19 THE COMMISSION. As provided by Section 82A-706.1, R.C.M., 1947, as amended, the Highway Commission is designated as a quasi-judicial board allocated to the Department of Highways for administrative purposes only.

01.20 DEPARTMENT OF HIGHWAYS. The State of Montana, Department of Highways acting through the Director and the Commission, when the State is the awarding authority. Where Department is used alone, it shall mean the Montana Department of Highways.

01.21 THE DIRECTOR. The chief administrative officer of the Department, as established by law, and such agents as are authorized to act in his behalf.

01.22 THE ENGINEER. The engineer designated by the Director to be the administrator of the Engineering Division, who in turn, acts through subordinate employees.

01.23 EQUIPMENT. All machinery and equipment, together with the necessary supplies for upkeep and maintenance, and also tools and apparatus necessary for the proper construction and acceptable completion of the work.

01.24 EQUIPMENT RENTAL RATES. Hourly rates, approved by the Montana Department of Highways for furnishing and operating various types of construction equipment.

01.25 EXTRA WORK. An item of work not provided for in the contract as awarded but found essential to the satisfactory completion of the contract within its intended scope.

01.26 EXTRA WORK ORDER. A work order concerning the performance of work or furnishing of materials involving extra work. Such extra work may be performed at agreed prices or on a force account basis as provided in Article 09.04.

01.27 FORCE ACCOUNT WORK. A course of action obligating the contractor to perform extra work when ordinary procedures of negotiation are unsuccessful. Such work to be paid for as specified in Article 09.04 (B).

01.28 HOLIDAYS. Chapter 19-107, Revised Codes of Montana states: (in abbreviated form)

The following are legal holidays in the State of Montana: Every Sunday; New Year's Day; Lincoln's Birthday; Washington's Birthday; Memorial Day; Independence Day; Labor Day; Columbus Day; Veterans' Day; Christmas Day and every day on which a general election is held throughout the State and every day appointed by the President of the United States or by the Governor of this State for a public fast, Thanksgiving or holiday. If any of the holidays herein enumerated (except Sunday) fall upon a Sunday, the Monday following is a holiday. All other days than those herein mentioned are to be deemed business days for all purposes, except as herein provided.

01.29 INSPECTOR. The engineer's authorized representative assigned to make detailed inspections of all work done and all materials furnished.

01.30 INVITATION FOR BIDS. The advertisement for proposals for all work or materials on which bids are required. Such advertisement will indicate with reasonable accuracy the quantity and location of the work to be done or the character and quantity of the material to be furnished and the time and place of the opening of proposals.

01.31 LABORATORY. The testing laboratory of the Montana Department of Highways or other testing laboratory which may be designated.

01.32 MAJOR ITEM. Items having an original contract value in excess of ten percent of the total original contract amount shall be classed as a major item.

01.33 MATERIALS. Substances specified for use in the construction of the project and its appurtenances.

01.34 MEDIAN. The portion of a divided highway separating the traveled ways for traffic in opposite directions.

01.35 NOTICE TO PROCEED. Written notice to the contractor to proceed with the contract work including the date of beginning of contract time.

01.36 PAVEMENT STRUCTURE. The combination of sub-base, base course, and surface placed on a subgrade to support the traffic load and distribute it to the roadbed.

01.37 PLANS. The approved plans, profiles, typical cross sections, working drawings and supplemental drawings, or exact reproductions thereof, which show the location, character, dimensions, and details of the work to be done.

01.38 PROFILE GRADE. The trace of a vertical plane intersecting the top surface of the proposed wearing surface, usually along the longitudinal centerline of the roadbed. Profile grade means either elevation or gradient of such trace according to the context.

01.39 PROJECT. The specific section of the highway together with all appurtenances and construction to be performed thereon under the contract.

01.40 PROPOSAL. The offer of a bidder, on the prescribed form to perform the work and to furnish the labor and materials at the prices quoted.

01.41 PROPOSAL FORM. The approved form on which the Commission requires bids to be prepared and submitted for the work.

01.42 PROPOSAL GUARANTY. The security furnished with a bid to guarantee that the bidder will enter into the contract if his bid is accepted.

01.43 PREQUALIFICATION QUESTIONNAIRE. The specified forms on which the contractor shall furnish required information as to his ability to perform and finance the work.

01.44 REASONABLY CLOSE CONFORMITY. Reasonably close conformity means compliance with reasonable and customary manufacturing and construction tolerances where working tolerances are not specified. Where working tolerances are specified, reasonably close conformity means compliance with such working tolerances. Without detracting from the complete and absolute discretion of the Engineer to insist upon such tolerance as establishing reasonably close conformity, the Engineer may accept variations beyond such tolerances as reasonably close conformity where they will not materially affect the value or utility of the work and the interests of the Government.

01.45 RIGHT-OF-WAY. A general term denoting land, property, or interest therein, usually in a strip, acquired for or devoted to a highway.

01.46 ROAD OR HIGHWAY. A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way.

01.47 ROADBED. The graded portion of a highway within top and side slopes, prepared as a foundation for the pavement structure and shoulders.

01.48 ROADSIDE. A general term denoting the area adjoining the outer edge of the roadway. Extensive areas between the roadways of a divided highway may also be considered roadside.

01.49 ROADSIDE DEVELOPMENT. Those items necessary to the complete highway which provide for the preservation of landscape materials and features; the rehabilitation and protection against erosion of all areas disturbed by construction through seeding, sodding, mulching and the placing of other ground covers; such suitable planting and other improvements as may increase the effectiveness and enhance the appearance of the highway.

01.50 ROADWAY. The portion of a highway within limits of construction.

01.51 SHOULDER. The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses.

01.52. SIDEWALK. That portion of the roadway primarily constructed for the use of pedestrians.

01.53 SPECIAL PROVISIONS. Additions and revisions to the standard and supplemental specifications covering conditions applicable to an individual project.

01.54 SPECIFICATIONS. A general term applied to all directions, provisions and requirements pertaining to performance of the work.

01.55 STANDARD DRAWINGS. Special drawings and sketches, including detailed instructions, where necessary, issued and made available by the engineer to the contractor and other interested persons. They will pertain to certain items of work contained in a contract.

01.56 STATE. The State of Montana acting through its authorized representative.

01.57 STREET. A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way within urban areas.

01.58 STRUCTURES. Bridges, culverts, catch basins, drop inlets, retaining walls, cribbing, manholes, endwalls, buildings, sewers, service pipes, underdrains, foundation drains and other features which may be encountered in the work and not other-wise classed herein.

01.59 SUB-BASE. The layer or layers of specified or selected material of designed thickness placed on a subgrade to support a base course.

01.60 SUBCONTRACTOR. All individuals, firms, partnerships, joint ventures or corporations to whom the contractor sublets part of the contract.

01.61 SUBGRADE. The top surface of a roadbed upon which the pavement structure and shoulders are constructed.

01.62 SUBSTRUCTURE. All of that part of the structure below the bearings of simple and continuous spans, skewbacks of arches and tops of footings of rigid frames, together with the backwalls, wingwalls and wing protection railings.

01.63 SUPERINTENDENT. The contractor's authorized representative in responsible charge of the work.

01.64 SUPERSTRUCTURE. The entire structure above the sub-structure.

01.65 SUPPLEMENTAL AGREEMENT. A written agreement executed by the contractor and the Commission, with the consent of the Surety, supplementing the original contract.

01.66 SUPPLEMENTAL SPECIFICATIONS. Additions and revisions to the standard specifications that are adopted subsequent to issuance of the printed book.

01.67 SURETY. The corporation, partnership or individual, other than the contractor, executing a bond furnished by the contractor.

01.68 SURFACE COURSE. The top layer of a pavement structure, designed to accommodate the traffic load and to resist traffic abrasion and the effects of climate.

01.69 TITLES (OR HEADINGS). The titles or headings of the sections and subsections herein are intended for convenience of reference and shall not be considered as having any bearing on their interpretation.

01.70 TOP SOIL. 1. Topsoil as referred to in Section 11, surface soil which is suitable for support of normal plant growth.

2. Topsoil as referred to in Section 17 is to be suitable for support of normal plant growth and shall meet the requirements of M-340.06.

01.71 TRAVELED WAY. The portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

01.72 WORK. Work shall mean the furnishing of all labor, materials, equipment, and other incidentals necessary or convenient to the successful completion of the project and the carrying out of all the duties and obligations imposed by the contract.

01.73 WORKING DAY. Any day shall be considered a working day except Saturdays, Sundays, Holidays designated as non-working days, and days on which the contractor is specifically required by the Special Provisions to suspend construction operations and all days during the period of November 16th through April 15th.

01.74 WORKING DRAWINGS. Stress sheets, shop drawings, erection plans, false work plans, framework plans, cofferdam plans, bending diagrams for reinforcing steel, or other supplementary plans or similar data which the contractor is required to submit to the engineer for approval.

01.75 AVOIDANCE OF REPETITION. In order to avoid cumbersome and confusing repetition of expressions in these specifications whenever it is provided that anything is, or is to be, or to be done, if or as, or when, or where "authorized," "contemplated," "required," "directed," "specified," "considered necessary," "deemed necessary," "permitted," "suspended," "approved," "acceptable," "unacceptable," "suitable," "unsuitable," "satisfactory," "unsatisfactory," or "sufficient," it shall be understood as if the expressions were followed by the words "by or to the engineer with the approval of the Department."

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SECTION 2

BIDDING REQUIREMENTS AND CONDITIONS

02.01 PREQUALIFICATION OF BIDDERS. All bidders shall be required to file an experience questionnaire and a confidential financial statement which must be certified prior to submitting a bid. The statement shall include a complete report of the bidder's financial resources and liabilities, equipment, past record, personnel, and must be submitted to The Commission at least seven calendar days prior to the date of opening bids on proposed work. Each prequalification statement shall meet the requirements of the current rules and regulations of the Commission.

Each individual, partnership, joint venture, corporation or association intending to bid upon proposals for the construction of highway projects, or to perform work thereon, shall submit, on Form No. PQ 59, a certified statement of qualifications concerning ability to perform the proposed work. The term "bidder" shall be interpreted hereinafter to include prospective bidder, contractor, and subcontractor. The title of said form shall be "Bidder's Prequalification Statement." The statement shall be prepared for and cover the Bidder's fiscal period and will be treated, by The Department of Highways, as "CONFIDENTIAL" matter. It shall remain in full force and effect, unless circumstances dictate a change, for one year, plus thirty days, after the end of the year covered by the statement. The Board will give consideration to a written request for an extension of that time. This statement shall be considered as essential part of the bid. A bid will not be accepted from any bidder who has not been considered, rated and approved by the Pre-qualification Board. A prospective Bidder, submitting a statement for the first time, and/ or a former prequalified bidder whose statement has expired, must submit data which is not more than 90 days old.

All persons or firms desiring to qualify or bid on highway construction on the basis of a Joint Venture shall be prequalified and shall also declare their intention by executing a "Declaration of Joint Venture and Power of Attorney." This instrument shall designate a name under which the members of the Joint Venture desire to do business with the Montana State Highway Commission and shall specifically authorize a person to execute all bids and contracts with the Montana State Highway Commission on

behalf of all members of the Joint Venture and which person shall be authorized to receive all moneys due from the Montana State Highway Commission to the Joint Venture and to issue binding receipts and releases therefor.

02.02 CONTENTS OF PROPOSAL FORMS. Forms will state the location and description of the contemplated construction and will show the approximate estimate of the various quantities and kinds of work to be performed or materials to be furnished, and will have a schedule of items for which unit bid prices are invited. The proposal form will state the time in which the work must be completed, the amount of the proposal guaranty, and the date, time and place of the opening of proposals. The form will also include any special provisions or requirements which vary from or are not contained in the standard specifications.

All papers bound with or attached to the proposal form are considered a part thereof and must not be detached or altered when the proposal is submitted.

The plans, specifications and other documents designated in the proposal form, will be considered a part of the proposal whether attached or not.

02.03 ISSUANCE OF PROPOSALS. The Commission will, upon request, furnish proposal forms and instructions to bidders. The Commission reserves the right to disqualify or refuse to issue a proposal other than informational forms if a bidder is in default for one or more of the following reasons:

(a) Lack of competency or lack of adequate machinery, plant and other equipment as revealed by the financial statement and experience questionnaire required under Article 02.01.

(b) Uncompleted work which, in the judgement of the Department, might hinder or prevent the prompt completion of additional work if awarded. When a contractor is working overtime on the completion of a project for the State of Montana or any board, commission or department thereof or by a Board of County Commissioners or by any city or town council or agency thereof in the construction or reconstruction of a public work and wishes to submit bids to the Commission, he will so notify in writing the Department of Highways in advance of advertising, designating the project and reason for the overtime and his proposed method of operation to execute the contract. The Director will then review the entire status of each of his contracts using Articles 02.01 and 02.03 and other

pertinent information as the guide for permitting the contractor to submit bids to the Commission. This review will be made at least three weeks prior to the opening of the bids and the contractors shall be notified in writing.

THE "HIGHWAY COMMISSION POLICY" & "PREQUALIFICATION PROCEDURE" SET FORTH BELOW IS FOR THE PURPOSE OF PROVIDING PROSPECTIVE CONTRACTORS WITH AN UNDERSTANDING OF THE DEPARTMENTS PREQUALIFICATION PROCEDURE IN RELATION TO THE STATE CONTRACTOR OVERTIME LAW.

HIGHWAY COMMISSION POLICY

The Montana Highway Commission in conference call on November 24, 1971 does by resolution direct the State Highway Engineer to provide for application of the State Contractor Overtime Law, Section 84-3507 and Section 82-1927, under the prequalification procedures and provides the following direction for his guidance.

The purpose of the contractor overtime law as enacted by the Legislature and understood by the executive bodies of the State of Montana is to strengthen prequalification procedures and deter contractors from sustaining liquidated damage assessments in lieu of completing projects. It is therefore determined to be in the public interest that the application of the law to accomplish the foregoing and to provide that all otherwise responsible bidders will be qualified to bid be implemented by this policy.

In order to accomplish this purpose and serve the public interest of Montana, the State Highway Prequalification Board is instructed to consider the circumstances involved in each individual case and make its determination of bidding qualification on the logical evaluation of the contractor's performance and capability and report its finding to the State Highway Engineer.

PREQUALIFICATION PROCEDURE FOR APPLICATION OF STATE CONTRACTOR OVERTIME LAW

The Director of Highways will have the contractor status on all active State construction projects accumulated at least 10 days prior to date of advertisement for bids. The status reports will include a clear concise summary of the status and the recommendation of the Division Construction Supervisors and the Construction Bureau Chief as to the logical application of the State law. The Director of Highways will review or have

the status reports reviewed for reasonable and uniform application of the law and is delegated the responsibility to take final action on behalf of the Department of Highways on the basis of the established Highway Commission Policy.

As the contractor status on other than State, i.e. local government, construction projects is not readily available, therefore the attached affidavit form will be provided in the contract documents to allow the prospective bidder after the date of advertisement to declare his compliance with the State law. Prior to the date of advertisement and during advertising period, the Director of Highways may disqualify a prospective bidder on the basis of the certified statement of an appropriate local government official in responsible supervision of the overtime contract and the Director of Highways determination of bidding qualification as outlined for State construction projects.

Prospective bidders disqualified by this procedure on or before the date of advertisement and during the advertising period may appeal the decision to the Director of Highways, and if sufficient information is presented to justify reversal of the decision on the basis of the foregoing, the bidder may be reinstated as qualified to bid prior to the time of bid opening and his bid may be accepted and read.

The Department of Highways, for the purpose of administering the State Contractor Overtime Law, Section 84-3507 and Section 82-1927, R.C.M., 1947, will not consider a contractor as working beyond the contract time if all but only minor items of work have been accomplished.

Minor items are those items that do not "materially affect" the newly constructed highway or which do not prevent the opening to the traveling public of this newly constructed highway, or in the case of a lighting, signing, landscaping or similar type project where the minor items do not "materially affect" the desired finished result of the construction project.

Items of work that do not "materially affect" the project may include, but shall not be limited to, seeding, sealing, painting, striping, fencing, guard rail, signing and landscaping of rest areas.

This provision does not alter or negate the provisions of Article 08-07 wherein liquidated damages may be assessed for the full value of the contract should this contract remain incomplete beyond the completion time set forth elsewhere in this proposal.

Further, under the provisions of Section 32-4102, R.C.M., 1947, as amended by Chapter 278, Laws of 1974, the Montana Highway Commission may waive enforcement of the provisions of Sections 84-3507 and 82-1927 when such enforcement would result in a reduction of the full benefits of the Federal Highway Act of 1921 and all amendments thereto.

- (c) Failure to pay, or satisfactorily settle, all bills due for labor and material on former contracts in force at the time of issuance of proposals.
- (d) Failure to comply with qualification regulations of the department.
- (e) Default under previous contracts.

02.04 INTERPRETATION OF QUANTITIES IN BID SCHEDULE. The quantities appearing in the bid schedule are approximate only and are prepared for the comparison of bids. The unit prices to be tendered by the bidder are to be tendered expressly for the scheduled quantities as they may be increased or decreased within the restricting percentage herein-after stipulated. Payment to the contractor will be made only for the actual quantities of work performed and accepted or materials furnished in accordance with the contract.

02.05 EXAMINATION OF PLANS, SPECIFICATIONS, SPECIAL PROVISIONS, AND SITE OF WORK. The Department will prepare full, complete, and accurate plans and specifications giving such directions as will enable them to be carried out by the contractor. The bidder is expected to examine carefully the site of the proposed work, the proposal, plans, specifications, supplemental specifications, special provisions, and contract forms, before submitting a proposal. The submission of a bid shall be considered prima facie evidence that the bidder has made such examination and is satisfied as to the conditions to be encountered in performing the work and as to the requirements of the plans, specifications, supplemental specifications, special provisions, and contract.

When sub-surface investigations have been made, the "Invitation for Bids" will indicate where bidders may inspect the investigation records.

The records of sub-surface investigations are not a part of the contract and are made available to bidders for informational purposes only.

While sub-surface investigations will have been performed with reasonable care, there is no warranty or guaranty, either expressed or implied, that they will disclose the actual conditions which will be encountered during the progress of the work.

When a log of test borings is included in the sub-surface investigation record, the data shown in the individual log of each test boring apply only to that particular boring taken on the date indicated and are not intended to be conclusive as to the character of any material or conditions between or around test borings at the time of examination of the site.

Any interpretation of the State's sub-surface investigation record made

by the bidder as to the types, characteristics, quantity or quality of any sub-surface material or condition shall be at the sole risk of the bidder.

02.06 PREPARATION OF PROPOSAL. The bidder shall submit his proposal on forms furnished by the Commission. The blank spaces in the forms must be filled in correctly for each and every item for which a quantity is given, and the bidder must state the prices (written both in words and numerals) for which he proposed or proposes to do each item of work contemplated. All proposals must be extended and totaled, and it is understood that, in cases of errors or discrepancies in extension, the unit prices written in words shall be held as governing. Extended figures will be corrected to the nearest one cent.

When an item in the proposal contains a choice to be made by the bidder, the bidder shall indicate his choice in accordance with the specifications for that particular item, and thereafter no further choice will be permitted. When the proposal contains alternates for various items, the bidder shall submit bids on all of the alternates and the Commission will select anyone of these alternates as a basis for the award of the contract.

The bidder must sign his proposal correctly, showing his name and post office address. If the proposal is submitted by a firm, partnership or joint-venture, the name and post office address of each member of the firm, partnership or joint-venture must be shown; if submitted by a corporation, the name of the State under the laws of which the corporation was chartered, and the names, titles and business addresses of the President and Secretary must appear.

02.07 IRREGULAR PROPOSALS. Proposals may be considered irregular and may be rejected for the following reasons:

- (a) If the proposal furnished is not used or is altered.
- (b) If there are unauthorized additions, conditional or alternate bids, or irregularities of any kind which may tend to make the proposal incomplete, indefinite or ambiguous as to its meaning.
- (c) If the proposals for two or more projects, advertised separately, are connected, or made contingent one upon the other, in such manner that the proposal for any particular project shall carry a provisional deduction in the bid price on one or more of the other projects.
- (d) If the bidder adds any unauthorized provisions reserving the right to accept or reject an award or to enter into a contract pursuant to an award.

(e) If the unit prices contained in the proposal are obviously unbalanced, either in excess or below the reasonable cost analysis value.

(f) If they fail to contain a unit price written in both words and numerals for every pay item indicated, except in the case of authorized alternate pay items.

02.08 PROPOSAL GUARANTY. No proposal will be considered unless accompanied by a proposal guaranty, in the amount stipulated by the proposal, made unconditionally payable to the Montana State Highway Commission, which at the bidder's option may be cash, cashier's check, certified check, postal money order, bank money order, express money order, bank draft, bid bond or any other guaranty that may be especially approved by the Commission. Alteration of the proposal form as required to provide for the form of guaranty will be allowed.

02.09 DELIVERY OF PROPOSALS. Each proposal should be submitted in a special envelope furnished by the department. The blank spaces on the envelope shall be filled in correctly to clearly indicate its contents. When an envelope other than the special one furnished by the Commission is used, it shall be of the same general size and shape and be similarly marked to clearly indicate its contents. If forwarded by mail, the above mentioned envelope may be enclosed in another, addressed to the Montana State Highway Commission, Helena, Montana; if forwarded otherwise than by mail it shall be delivered at the office of the Montana State Highway Commission, Helena, Montana.

Proposals will be received until the date and hour set for the opening of bids and must be in the hands of the Commission by that time. The responsibility for delivery of the proposals shall be solely that of the bidder. All proposals delivered after the time for opening of bids will not be considered and will be returned to the bidder un-opened.

The Commission does not recognize any communications or transportation facility, public or private, as its agent for accepting bid proposals.

No responsibility will be attached to the Commission for the premature opening of a bid not properly addressed and identified.

02.10 WITHDRAWAL OR REVISION OF PROPOSALS. A bidder may withdraw a proposal after it has been deposited with the Commission, provided the request for withdrawal is received by the Commission in writing or by telegram, before the time set for opening proposals. It is

further provided that when a proposal is opened at the reading of bids, a bidder may withdraw any bid in person or through his authorized agent before any bids on that project are read.

Revisions to proposals already deposited with the Commission will be accepted prior to the time set for opening proposals. All such revisions shall be submitted in writing subject to the conditions of Article 02.09.

02.11 COMBINATION OR CONDITIONAL BIDS. On certain projects a bidder may submit bids on more work than he desires to have awarded to him. He may indicate the total amount he desires to accept and the Commission will determine which of his low bids on these projects, up to the final total indicated will be accepted. This limitation will only apply to those projects on which the following statement has been included in the proposal and is properly filled in by the contractor.

We desire to disqualify all of our bids at this letting which exceed the total of \$_____ or _____ contracts and hereby authorize the Commission to determine which bids shall be disqualified.

A proposal guaranty, conforming to article 02.08 in the amount of \$_____ accompanies the proposal for project number _____ or has been filed with the department in advance.

02.12 PUBLIC OPENING OF PROPOSALS. Proposals will be opened and read publicly at the time and on the date set forth in the "Invitation for Bids", by the Commission in Helena, or at such other place as may be designated. Bidders, their authorized agents, and other interested parties are invited to be present.

02.13 DISQUALIFICATION OF BIDDERS. Either of the following reasons may be considered as being sufficient for the disqualification of a bidder and the rejection of his proposal or proposals:

(a) More than one proposal for the same work from an individual, firm, corporation, partnership or joint venture under the same or different name.

(b) Evidence of collusion among bidders. Participants in collusion will receive no recognition as bidders either singly or joint venture, for future work of the Commission until each participant has been reinstated as a qualified bidder.

If it shall be found that a bidder is interested in more than one proposal for the work contemplated, the Commission will cause the rejection of all proposals in which that bidder is interested.

02.14 MATERIAL GUARANTY. The successful bidder may be required to furnish a complete statement of the origin, composition, and manufacture of all materials to be used in the construction of work together with samples which may be subjected to the tests provided for in these specifications to determine their quality and fitness for the work.

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SECTION 3

AWARD AND EXECUTION OF CONTRACT

03.01 CONSIDERATION OF PROPOSALS. After the proposals are opened and read, they will be compared on the basis of the summation of the products of the approximate quantities shown in the bid schedule by the unit bid prices, written in words. The results of such comparisons will be immediately available to the public. In the event of discrepancy between unit bid prices and extensions, the unit bid price shall govern.

The Commission reserves the right to reject any or all proposals, to waive technicalities or to advertise for new proposals.

03.02 AWARD OF CONTRACT. The award of contract, if awarded, will be made within 45 calendar days after the opening proposals to the lowest bidder whose proposal complies with all the requirements prescribed. The successful bidder will be notified, by letter mailed to the address shown on his proposal, that his bid has been accepted and that he has been awarded the contract.

If an award is not made within 45 calendar days, all proposals will be rejected and guaranties returned unless extended by the Commission.

03.03 CANCELLATION OF AWARD. The Commission reserves the right to cancel the award of a contract at any time before the execution of said contract by all parties without liability against the Commission and/or the Department of Highways.

03.04 RETURN OF PROPOSAL GUARANTY. All proposal guaranties other than bid bonds, except those of the three lowest bidders, will be returned immediately following the opening and checking of the proposals. The retained proposal guaranty of the unsuccessful of the three lowest bidders will be returned within ten days following the award of contract and that of the successful bidder will be returned after a satisfactory bond has been furnished and the contract has been executed.

03.05 REQUIREMENT OF CONTRACT BOND. At the time of the execution of the contract, the successful bidder shall furnish a surety

bond or bonds in a sum equal to the full amount of the contract. The surety bond or bonds shall be in a form acceptable to the Commission. The surety bond or bonds shall be executed by the surety company authorized by law to transact such business in the State of Montana.

03.06 EXECUTION AND APPROVAL OF CONTRACT. The individual, partnership, joint venture, firm or corporation to whom or to which the contract has been awarded shall enter into a contract with the Commission within ten days after receipt of the contract documents. When the contract, after execution by the contractor, is returned to the Commission it shall be accompanied by a copy of the policy or a certificate of insurance. A proposal will not be considered binding upon the Commission until the contract has been properly executed and evidence of insurance furnished as stated.

The contractor shall not be permitted, under any circumstances, to begin work, nor will payment be made for materials delivered, prior to execution of the contract and filing of required insurance. The contract shall be subject to legal approval after execution by the contractor and by the chairman of the Commission. The bond and insurance shall be approved likewise after execution by the contractor and surety. Insurance shall conform to the requirements of Article 07.15.

03.07 FAILURE TO EXECUTE CONTRACT. Failure to execute the contract and file acceptable bonds within ten days after the award of the contract, or within such further time as the Director may allow, shall be cause for the cancellation of the award and the forfeiture of the proposal guaranty which shall become the property of the Department, not as a penalty, but in liquidation of damages sustained. Award may then be made to the next lowest responsible and qualified bidder, or the work may be readvertised and constructed under contract or otherwise, as the Department may decide.

SECTION 4

SCOPE OF WORK

04.01 INTENT OF CONTRACT. The intent of the contract is to provide for the construction and completion in every detail of the work described. The contractor shall furnish all labor, materials, equipment, tools, transportation and supplies required to complete the work in accordance with the plans, specifications and terms of the contract. It shall be understood that the work to be done will not necessarily be limited to within the Highway right-of-way.

04.02 ALTERATION OF PLANS OR CHARACTER OF WORK.

(A) General. The Department reserves the right to make, at any time during the progress of the work, such increases or decreases in quantities and such alterations in the work within the general scope of the contract, including alterations in the grade or alignment of the road or structure or both as may be found to be necessary or desirable. Such increases or decreases and alterations shall not invalidate the contract nor release the surety, and the Contractor agrees to accept the work as altered, the same as if it had been a part of the original contract.

Under no circumstances shall alterations of plans or of the nature of the work involve work beyond the termini of the proposed construction except as may be necessary to satisfactorily complete the project.

Unless such alterations, increases or decreases materially change the character of the work to be performed or the cost thereof, the altered work shall be paid for at the same unit prices as other parts of the work. If the character or quantity of the work or the unit costs thereof are materially changed, an allowance shall be made on such basis as may have been agreed to in advance of the performance of the work, or in case no basis has been previously agreed upon, then an allowance shall be made, either for or against the contractor, in such amount as the engineer may determine to be fair and equitable.

No claim shall be made by the contractor for any loss of anticipated profits because of any such alteration or by reason of any variation between the approximate quantities and the quantities of work as done.

If altered or added work is of sufficient magnitude as to require additional time in which to complete the project, such time adjustments may be made in accordance with the provisions of Subsection 08.06.

Should the contractor encounter or the Department discover during the progress of the work subsurface or latent physical conditions at the site differing materially from those indicated in this contract, or unknown physical conditions at the site of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in work of the character provided for in the contract, the engineer shall be promptly notified in writing of such conditions before they are disturbed. Such written notification must be transmitted to the engineer within 15 days of the discovery of the change or variation. The engineer will thereupon promptly investigate the conditions and if he finds they do so materially differ and cause an increase or decrease in the cost of, or the time required for performance of the contract, an equitable adjustment will be made and the contract modified in writing accordingly.

(B) Supplemental Agreement: Either party to the contract may demand, in writing, that a supplemental agreement or change order be prepared to authorize an adjustment in the basis of payment, or; they may agree that payment be made at unit prices or agreed prices, as documented and authorized by change order, when one or a combination of the following four conditions occur:

(1) An increase or decrease of more than 25 percent in the length of the project as initially contracted.

(2) An increase or decrease of more than 25 percent of the total cost of the work calculated from the original contract quantities at the unit contract prices.

(3) An increase or decrease of more than 25 percent in the quantity of any one major contract item, including the types of excavation defined by Article 11.02; but not including excavation of any other class or items of foundation piling.

(4) The quantity of extra work exceeds 25 percent of the original price of the total contract amount.

An adjustment in payment for a quantity increase, under the conditions described in (2) and (3) above, shall apply only to those quantities greater than the initial 25 percent increase. An adjustment in payment for quantity decrease, under the conditions described in (2) and (3) above, shall apply to the quantity of work actually performed. In the case of decreased quantities of work, no allowance shall be made in the supplemental agreement for anticipated profits.

A supplementary agreement will describe the extra or additional work completely, state the agreed prices at which the completed work will be paid and will include the approximate quantities of work as estimated prior to performance of the work. The supplemental agreement shall be

executed by both parties to the original contract and shall become a part of the original contract. Payment for the work included under the terms of the supplemental agreement will be made at the prices set forth therein and for the actual quantity of work performed.

The contractor shall either submit written evidence or deposit a surety bond with the Commission, that fully covers the amount of all work involved in an increase contemplated by the supplemental agreement.

If a supplemental agreement or a change order utilizing contract unit prices or agreed prices cannot be agreed upon, the work in dispute may be cancelled from the contract or it may be ordered to be performed on a Force Account basis. If the Force Account method of payment is unacceptable to either party an alternate method of payment shall be agreed upon before work is started on that portion of the work or the major contract item concerned in excess of the 25% increase or decrease. The alternate method of payment shall take into account a redistribution of fixed overhead costs and shall apply only to those major contract item quantities or work in excess of the 25% increase or decrease.

(C) Change Order: A change order may be used to authorize a substantial change in a contract item or changes in materials, or design changes or extra work performed at agreed unit prices. A change order, if used in place of a supplemental agreement, will include the requirements outlined in (B) above for supplemental agreements.

04.03 EXTRA WORK. The contractor shall perform extra work whenever it is in the public interest to do so, or required to complete the work as contemplated. Extra work shall be performed in accordance with specifications and as directed. Payment for extra work is described in Article 09.04.

Extra work performed prior to or without a written order for the work, executed by both parties, will not be paid for.

Extra work may be performed as described in these specifications or that portion of the work including extra work may be deleted from the contract or the entire contract may be cancelled, if the State determines it is in the public interest to do so.

04.04 MAINTENANCE OF THE WORK

(A) General. The contractor shall keep constructed or installed parts of the project in satisfactory condition by daily performance of effective work, with adequate equipment and forces, until acceptance of the project.

Maintenance of the work includes but is not limited to: 1. Patching chuck holes with asphalt mix. 2. Re-shaping the subgrade, side slopes, ditch sections, or aggregate courses, when necessary. 3. Cleaning debris from drainage courses, culverts and inlets. 4. Cleaning traffic control devices. 5. Removing rocks or earth from the roadway and ditch sections. 6. Removing debris caused by construction activities. 7. Providing access to residences, businesses and roads or keeping the present accesses open. 8. Repair or replacement of damaged parts of the work or installations. 9. Special maintenance. 10. Maintenance of detours and traffic. 11. Maintenance of the constructed roadway. 12. Disposing of removed matter. 13. Maintenance of irrigation water.

The cost of maintenance work with the exception of construction signing, flagging and pilot car operation performed before the project, or parts of it, is accepted shall be included in the unit prices for the various contract items, unless otherwise provided. The contractor will not be paid an additional amount for such work. The contractor will be relieved of maintenance of completed and accepted parts of the project which have been accepted.

In the case of a contract for the placing of a course upon a course or subgrade previously constructed, the Contractor shall maintain the previous course or subgrade during all construction operations.

Removal of snow from roads, connections, approaches and detours used by public traffic will be done by the Department during a winter shut-down and at other times when the daily accumulation of snow is excessive. The contractor shall remove snow, for his own operations from areas not used by public traffic.

(B) Special Maintenance. The engineer may direct special maintenance, for the benefit of the traveling public, or to cover repair of extensive damage from causes not under the contractor's control. Payment for special maintenance will be at unit prices or as extra work. The engineer will be the sole judge of the work to be classed as special maintenance.

(C) Maintenance For Traffic And Detours.

(1) Maintenance for Traffic. The road undergoing improvements shall be kept open to all traffic or suitable roads shall be provided for movement of traffic around parts or all of the project.

The contractor shall provide for traffic, as directed, by maintaining the road undergoing improvements, in addition to constructing and maintaining approaches, crossings, intersections, connections, detours, and access to parking lots, garages, businesses, residences, farms and like

facilities without direct compensation except when contract items are provided or special maintenance is directed.

(2) Special Detours. When the contract contains an item for "Maintenance of Detours" or "Removing Existing Structures and Maintaining Traffic," payment for such items shall cover all cost of constructing and maintaining such detour or detours, including the construction and removal of temporary bridges and their accessory features and obliteration of the detour road.

Right-of-way for temporary highways or bridges called for under the above paragraph will be furnished by the Department. All or any portion of an existing structure that is suitable for use may be utilized in the detour. Any modification of an existing structure or construction of a temporary structure shall require approval prior to prosecuting the work.

(3) Maintenance For Traffic During Suspensions of work.

(A) Temporary Suspension. Before a temporary suspension of work, the contractor shall make passable and shall open to traffic portions of the project, connections and temporary roadways, as directed. The contractor shall maintain the work, parts of the project, connections and temporary roadways used by traffic, in a satisfactory condition at no cost to the Department, except where the contract contains an item or items for maintenance of detours and temporary roadways such as "Maintenance of Detours" or "Removing Existing Structures and Maintaining Traffic".

(B) Winter Suspension. Before a contractor suspends work due to winter or seasonal weather, including the time during the period of November 16th through April 15th, he shall accommodate traffic by opening such portions of the project and temporary roadways or portions thereof as may be directed by the engineer. Before maintenance is assumed by State or County forces the contractor shall place those portions of the project opened to traffic and all temporary roadways in a safe, smooth driving condition. During the winter shutdown period, the maintenance of temporary roadways or portions of the project opened to traffic will be as follows:

(a) When the contractor has ceased all operations on the project, as ordered by the engineer, maintenance will be by and at the expense of the Department or the county, whichever applies.

(b) When the contractor is engaged in work not affecting the roadway, (stockpiling, drilling and blasting, etc.,) maintenance will be by and at the expense of the Department.

(c) When the contractor is engaged in work utilizing the roadway

(hauling, crossing over, etc.,) he shall be responsible for the maintenance of the portions of the roadway affected.

(d) During the period of winter suspension, should the temporary travelled way require maintenance beyond the capabilities of Department or County Maintenance forces, such maintenance shall be performed by the contractor on a force account basis.

(e) When work is resumed after a winter shutdown period, the contractor shall again assume responsibility for maintenance of the project. After work is resumed the contractor shall replace or renew any work or materials lost or damaged because of such temporary use of the project; shall remove to the extent directed by the engineer any work or materials used in the temporary maintenance thereof by the Department; and shall complete the project in every respect as though its prosecution had been continuous and without interferences. All additional work caused by such suspensions, for reasons beyond the control of the contractor, will be paid for by the Department at contract prices or by extra work.

(4) Maintenance Of Traffic Control Devices During Seasonal Suspension Of Work. Before an authorized seasonal shutdown, the contractor shall furnish and install all necessary traffic control devices in conformance with the requirements of the MUTCD Part VI, on the portions of the highway under improvement and on such temporary roadways or portions thereof as may be directed by the engineer. Thereafter, and until the issuance of an order for the resumption of construction operations, the maintenance shall be by and at the expense of the Department.

When work is ordered resumed after a seasonal shutdown, the Contractor shall again assume the responsibility for maintaining all traffic control devices on the project. Traffic control devices used previously on the project which were removed at the start of the suspension of work, shall be replaced.

(5) Provisions for Traffic Control.

(a) General. The contractor shall take all necessary precautions for the protection of the work and safety of the public. Highways closed to traffic shall be protected by effective traffic control devices.

No work shall commence until the immediate construction area has been adequately signed and approved by the engineer. Signs shall conform to the latest edition of the "manual on Uniform Traffic Control Devices for Streets and Highways," as published by the U.S. Government Printing Office, the construction signing standards, or standard drawings, where modified. Warning signs which the contractor may have on hand may be used with approval of the engineer, provided they contain the re-

quired legend, conform to the requirements of the MUTCD and are in good condition.

No speed limits shall be set up by the contractor unless authorized by the engineer or State statute. Speed limits shall be for a temporary period only, and shall be removed at the direction of the engineer.

The contractor shall furnish, erect, maintain, and upon completion of their function, remove all barricades, danger signals, signs, pilot vehicles, signals, or other traffic control devices necessary to warn and direct the traveling public through or around construction operations. The method of fabricating and erecting traffic control devices will be as specified in the Standard Specifications, Standard Drawings, and the Construction Signing Standards. Traffic control devices shall be used at locations shown on the plans, for a distance of one-half mile outside each end of the project, at points outside the project where construction equipment crosses or enters a highway and where directed.

Such facilities as colored lights, lanterns, artificial lighting and the like shall be operated from sunset to sunrise when necessary. Approved types of flashing signals may be required as occasion demands. Flagmen shall be used to the extent necessary to protect the public.

The wearing apparel and equipment of the contractor's flagmen shall conform to the requirements set forth by the current issue of the manual entitled "INSTRUCTIONS TO FLAGMEN" as issued by the Department.

All materials for construction signs and barricades shall meet the requirements of Section 88 of the Standard Specifications and in the book of Standard Drawings.

All maintenance of traffic control devices shall be the responsibility of the contractor, except during a seasonal suspension of work. Maintenance shall include removal of dirt or other foreign material from sign faces as well as immediate repair or replacement of damaged traffic control devices.

(b) Method of Measurement. The basis of measurement for traffic control shall be as follows:

1. The actual number of each type of sign provided and installed for the duration of its need at one location including portable signs relocated to another point. Minor shifts in location of portable signs or temporarily facing signs away from traffic will not be measured as a sign relocation.
2. The actual number of hours of approved flagmen services.
3. The actual number of hours of approved pilot car operation.

(c) Basis of Payment. Payment for "Traffic Control," determined as

provided above, shall be made at the rates set forth in the special provision for construction sign rate schedule.

Traffic control items are to be used only as directed. The final cost may vary considerably from the estimated amount set forth in the contract.

Upon completion and acceptance of the work, all construction signs shall be removed. The salvaged signs shall remain the property of the contractor, excepting those furnished by the Department.

(6) Maintenance Of Irrigation Water. Whenever, during the course of construction, it becomes necessary that irrigation water be made available for crops, the various structures, boxes, channel changes and culverts which are affected, or are related to irrigation, shall be constructed or moved in such manner as to maintain sufficient flow of irrigation water.

The contractor shall not shut off irrigation water in an irrigation ditch without first consulting the water master or owner of the ditch and securing written permission for the period during which water may be shut off in each and every irrigation ditch.

(7) Maintenance of Roadway During Construction.

See Article 11.03(j).

(8) Final Cleaning Up.

Before final acceptance, the highway, borrow pits, and all ground occupied by the contractor in connection with the work shall be cleaned of all rubbish, debris, excess materials, temporary structures, and equipment. All parts of the work shall be placed in an acceptable condition.

Final cleanup for borrow material or aggregate areas, unless otherwise provided shall conform to the provisions of Article 06.02.

The contractor shall make the necessary arrangements for the relocation or adjustment of all pole lines crossing Department optioned or contractor selected pit areas. Unless otherwise directed, excavation shall be performed in a manner that assures that no pole shall be left on a knoll within the pit area after excavation of the pit is complete. Knolls existing before excavation begins shall be removed as well as contractor caused knolls.

The work required for final cleaning up of the pits, borrow areas or quarries will not be paid for directly but will be considered incidental to the payment for other items in the contract. The contractor shall make no agreement with any landowner unless the prescribed cleanup shall be agreed upon and done.

04.05 RIGHTS IN AND USE OF MATERIALS FOUND ON THE WORK.

The contractor may use, in the construction of the surface or structures, materials found on the project that meet all the requirements of the specifications relating to character and quality for the particular use intended. Materials so used and paid for under some item, will not be paid for as "Excavation," "Clearing," "Rip-rap," etc., except that when materials contemplated for use in embankments are otherwise used by the contractor with the result that borrow, not originally contemplated, is necessitated the contractor will be paid on a basis that is most economical for the Department. The contractor shall not excavate or remove any material from within the right-of-way which is not within the excavation as indicated by the slope and grade lines, without written authorization. In no instance will an item be paid for under the dual identity.

The material from any existing old structure may be used temporarily by the contractor in the erection of the new structure unless otherwise provided. Such material shall not be cut or otherwise damaged except with the approval of the engineer.

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SECTION 5

CONTROL OF WORK

05.01 AUTHORITY OF THE ENGINEER. The engineer will decide all questions which may arise as to the quality and acceptability of materials furnished and work performed and as to the rate of progress of the work; all questions which may arise as to the interpretation of the plans and specifications; all questions as to the acceptable fulfillment of the contract on the part of the contractor.

The engineer will have the authority to suspend the work wholly or in part due to the failure of the contractor to correct conditions unsafe for the workmen or the general public; for failure to carry out provisions of the contract; for failure to carry out orders; for such periods as he may deem necessary due to unsuitable weather; for conditions considered unsuitable for the prosecution of work or for any other condition or reason deemed to be in the public interest.

05.02 PLANS AND WORKING DRAWINGS. Plans and working drawings will be furnished by the Department and in all cases they will form a part of the contract. The plans will show, in detail, minor structures, alignments, grades, cross sections or cross section data in tabular form, of the improvement. Bridge plans will be furnished and will show the general layout and features and all necessary details pertaining to structures. Such supplementary bridge and falsework plans, shop details, and the like, as may be necessary shall be furnished by the contractor, but shall not be used until after approval of the engineer. No extra compensation will be allowed for such drawings. Alterations authorized by the engineer will be endorsed on approved plans or shown on supplementary sheets. Additional details relative to working drawings will be furnished as required. It shall be expressly understood that the approval by the engineer of the contractor's working drawings relates to the requirements for strength and detail and such approval will not relieve the contractor from the responsibility for errors in dimensions.

05.03 CONFORMITY WITH PLANS AND SPECIFICATIONS. All work performed and all materials furnished shall be in substantial conformity with the lines, grades, cross sections, dimensions, and material requirements, including tolerances, shown on the plans or indicated in the specifications.

Plan dimensions and contract specification values are to be considered as the target value to be strived for and complied with as the design value from which any deviations are allowed. It is the intent of the specifications that the materials and workmanship shall be uniform in character and shall conform as nearly as realistically possible to the prescribed target value or to the middle portion of the tolerance range. The purpose of the tolerance range is to accommodate occasional minor variations from the median zone that are unavoidable for practical reasons. When a maximum or minimum value is specified, the production and processing of the material and the performance of the work shall be so controlled that the material or work will not be preponderately of borderline quality or dimension.

When the engineer finds the materials, or the finished product in which the materials are used not in substantial conformity with the plans and specifications, but that work adequate to serve the design purpose has been produced, he shall then determine, to what extent the work will be accepted and remain in place. The engineer will in this event document the basis of acceptance by contract modification which will provide for an adjustment in the contract price for such work or materials as he deems necessary to conform to his determination based on engineering judgment.

When the engineer finds the materials, or the finished product in which the materials are used or the work performed are not in substantial conformity with the plans and specifications and have resulted in work inadequate to serve the design purposes the work or materials shall be removed and replaced or otherwise corrected by and at the expense of the contractor.

05.04 COORDINATION OF PLANS, SPECIFICATIONS, SUPPLEMENTAL SPECIFICATIONS, AND SPECIAL PROVISIONS. These specifications, the supplemental specifications, the plans, special provisions, and all supplementary documents are essential parts of the contract, and a requirement occurring in one is binding as though occurring in all. They are intended to be complementary and to describe and provide for a complete work. If a discrepancy exists, calculated dimensions, unless obviously incorrect, will govern over scaled dimensions; supplemental specifications will govern over standard specifications; plans will govern over standard and supplemental specifications; special provisions will govern over standard specifications, supplement specifications and plans.

The contractor shall not take advantage of an apparent error or

omission in the plans or specifications. If the contractor discovers such an error or omission, he shall immediately notify the engineer. The engineer will then make such corrections and interpretations as may be deemed necessary for fulfilling the intent of the plans and specifications.

05.05 COOPERATION BY CONTRACTOR. The contractor will be supplied with a minimum of two sets of approved plans and contract assemblies including special provisions, one set of which the contractor shall keep available on the work at all times.

The contractor shall give the work the constant attention necessary to facilitate the progress thereof, and shall cooperate with the engineer, his inspector, and other contractors in every way possible.

The contractor shall have on the work at all times, as his agent, a competent superintendent capable of reading and thoroughly understanding the plans and specifications and thoroughly experienced in the type of work being performed, who shall receive instructions from the engineer or his authorized representatives. The contractor shall notify the engineer, in writing, in advance of the start of work or, in advance of his absence, the name of his superintendent who shall be on the job site at all times while the work is in progress.

The superintendent shall have full authority to execute orders or directions of the Engineer without delay, and to promptly supply such materials, equipment, tools, labor and incidentals as may be required. Such superintendence shall be furnished irrespective of the amount of work sublet.

05.06 COOPERATION WITH UTILITIES. The department will notify all utility companies, all pipe line owners, or other parties affected, and endeavor to have all necessary adjustments of the public or private utility fixtures, pipe lines and other appurtenances within or adjacent to the limits of construction, made as soon as practicable.

Water lines, gas lines, wire lines, service connections, water and gas meter boxes, water and gas valve boxes, light standards, cableways, signals, and all other utility appurtenances within the limits of the proposed construction which are to be relocated or adjusted are to be moved by the owners except as otherwise provided for in the special provisions or as noted on the plans.

It is understood and agreed that the contractor has considered in his bid all of the permanent and temporary utility appurtenances in their present or relocated positions as shown on the plans and that no additional compensation will be allowed for all delays, inconvenience, or damage

sustained by him due to interference from the said utility appurtenances or the operation of moving them.

The contract in general will indicate various utility items, certain of which are to be relocated or adjusted by the utility owner and others which are to be relocated or adjusted by the contractor. The special provision will indicate the means of adjudication, if any, in case of failure by the utility owners to comply with their responsibility in relocating or adjusting their facility.

05.07 COOPERATION BETWEEN CONTRACTORS. The Department reserves the right to contract for and perform other or additional work on or near the work covered by the contract at all times.

When separate contracts are let within the limits of the same project, each contractor shall conduct his work so as not to interfere with or hinder the progress or completion of the work being performed by other contractors. Contractors working on the same project shall cooperate with each other as directed.

Each contractor involved shall assume all liability, financial or otherwise, in connection with his contract and shall protect and save harmless the Department from any and all damages or claims that may arise because of inconvenience, delay, or loss experienced by him because of the presence and operations of other contractors working within the limits of the same project.

The contractor shall arrange his work and shall place and dispose of the materials being used so as not to interfere with the operations of the other contractors within the limits of the same project. He shall join his work with that of the others in an acceptable manner and shall perform it in proper sequence to that of the others. Each contractor shall confine storing of materials, tools, machinery or other equipment to his own respective right-of-way or other area outside of the highway so as not to interfere with or impede the work of the other.

05.08 CONSTRUCTION STAKES, LINES AND GRADES. The engineer will set construction stakes establishing lines, slopes, and continuous profile-grade in road work, and centerline and bench marks for bridge work, culvert work, protective and accessory structures and appurtenances as he may deem necessary, and will furnish the contractor with all necessary information relating to lines, slopes and grades. These stakes and marks will constitute the field control by and in accordance with which the contractor shall establish other necessary controls and perform the work.

The contractor shall be held responsible for the preservation of all stakes and marks. If construction stakes or marks are carelessly or willfully destroyed or disturbed by the contractor, the cost of replacing them will be charged against him and will be deducted from the payment for the work.

The contractor shall furnish the inspector, free of charge, such reasonable assistance or assistants as may be required in giving points and lines necessary to the prosecution of the work.

The Department will be responsible for the accuracy of lines, slopes, grades, and other engineering work which is set forth under this section.

The contractor shall take no advantage of any apparent error, omission or delay by the Department in performing construction staking, or other engineering work. When such apparent error, omission or delay is discovered, work shall cease on affected contract items. The contractor shall file a written complaint with the Department within ten days after the time the apparent error, omission or delay was discovered. Any claim for adjustment, after the ten day period, will not be considered for payment.

05.09 AUTHORITY AND DUTIES OF ENGINEER ON CONSTRUCTION. Each project will have an Engineer designated as a representative of the Contracting Officer, with authority in accordance with subsection 05.01. The Contractor will be notified of the identity of this Engineer before work has begun.

05.10 AUTHORITY AND DUTIES OF INSPECTORS. Inspectors, employed by the Department, will be authorized to inspect all work done and all materials furnished. Such inspection may extend to all or any part of the work and to the preparation or manufacture of the materials to be used; but such inspection shall not relieve the contractor from any obligation to perform all of the work substantially in accordance with the requirements of the contract. If a dispute arises between the contractor and the inspector as to materials furnished, or the manner of performing the work, the inspector will have the authority to reject materials or suspend prosecution of the particular work affected until the questions at issue can be referred to and decided by the engineer. The inspector will not be authorized to revoke, alter, enlarge, or relax any requirements of the contract, nor to finally approve or accept any portion of work, not to issue instructions contrary to the provisions of the plans and specifications. Advice inconsistent with the requirements of the contract, which the inspector may give the contractor, shall not be construed as binding the engineer or the Department in any way, nor releasing the contractor from the fulfillment of the terms of the contract. The inspector or engineer will

not be permitted to act as foreman for the contractor, not to interfere with the management of the work.

05.11 INSPECTION OF WORK. All materials and each part or detail of the work shall be subject to inspection by the engineer. The engineer will be allowed access to all parts of the work and shall be furnished with such information and assistance by the contractor as required to make a complete and detailed inspection.

If the engineer requests it, the contractor, at any times before acceptance of the work, shall remove or uncover such portions of the finished work as may be directed. After examination, the contractor shall restore said portions of work to the standard required by the specifications. Should the work thus exposed or examined prove acceptable, the uncovering or removing, and the replacing of the covering or making good of the parts removed will be paid for as extra work; but should the work so exposed or examined prove unacceptable the uncovering, or removing, and the replacing of the covering or making good of the parts removed, will be at the contractor's expense.

Work done or materials used without supervision or inspection by an authorized Department representative may be ordered removed and replaced at the contractor's expense.

When a unit of government or political subdivision or railroad corporation is to pay a portion of the cost of the work covered by this contract, its respective representatives shall have the right to inspect the work. Such inspection shall not make the unit of government or political subdivision or railroad corporation a party to this contract, and shall in no way interfere with the rights of either party hereunder.

05.12 REMOVAL OF UNACCEPTABLE AND UNAUTHORIZED WORK. All work which does not meet the requirements of the contract will be unacceptable, unless otherwise determined acceptable under Article 05.03. Unacceptable work shall be removed and replaced.

No work shall be done unless lines and grades have been established by the engineer. Work done contrary to the instructions of the engineer, work done beyond the lines shown on the plans, or as given, except as herein specified, or any extra work done without authority, will not be paid for under the provisions of the contract. Work so done may be ordered removed or replaced at the contractor's expense. The contractor shall, in no event, incur any liability by reason of any verbal directions or instructions that he may receive from the engineer; nor shall the Department be liable for any extra materials furnished or used, or for any extra

work or labor done, unless the materials, work or labor are required of the contractor by written order from the engineer.

Upon failure on the part of the Contractor to comply forthwith with any order of the Engineer made under the provisions of this article, the Engineer will have authority to cause unacceptable work to be remedied or removed and replaced and unauthorized work to be removed and to deduct the costs from any monies due or to become due the Contractor.

05.13 MAINTENANCE DURING CONSTRUCTION. The contractor shall maintain the work during construction and until the project is accepted. This maintenance shall constitute continuous and effective work prosecuted day by day, with adequate equipment and forces so that the roadway or structures are kept in satisfactory condition at all times.

Unless otherwise specified, cost of maintenance work during construction and before the project is accepted shall be included in the unit prices bid for the various pay items and the contractor will not be paid an additional amount for such work except for water as provided in section 13.52B.

05.14 FAILURE TO MAINTAIN ROADWAY OR STRUCTURE. If the contractor fails to comply with the provisions of Article 05.13, the engineer will immediately notify the contractor of this non-compliance. If the contractor fails to remedy unsatisfactory maintenance within 24 hours after receipt of such notice, the engineer may immediately proceed to maintain the project, and the entire cost of this maintenance will be deducted from monies due or to become due the contractor on his contract.

05.15 FINAL INSPECTION. When the contractor provides proper notice of completion of the entire project, the engineer will arrange to make a final inspection. Where all work is complete but deferment of final inspection is necessary due to causes not within the control of the contractor, and due solely to these causes, the engineer will issue a suspend work order and not time charge shall accrue against the contractor for such elapsed period. If all construction provided for and contemplated by the contract is found completed to his satisfaction, that inspection shall constitute the final inspection and the engineer will notify the contractor in a certificate of completion that the work has been completed as of the date of the final inspection.

If the inspection discloses unsatisfactory work, the engineer will give the contractor the necessary instructions for correction, and the contractor shall immediately comply. When the contractor has corrected

the deficiencies, another inspection will be made and provided the work has been satisfactorily completed, the engineer then will make the final inspection and notify the contractor in writing, of this completion as of the date of final inspection, as set forth in the above paragraph.

The engineer will then recommend to the Department that final acceptance of the project be made and such final acceptance will be made by the Department at its next regular meeting after receipt of the certificate of completion and recommendation from the engineer. Upon acceptance of the completed contract by the Department, the engineer will notify the contractor and his surety of the acceptance.

05.16 CLAIMS FOR ADJUSTMENT AND DISPUTES. If the contractor deems that additional compensation is due him for work or material not clearly covered in the contract or not ordered by the engineer as extra work, as defined herein, the contractor shall notify the engineer in writing of his intention to make claims for such additional compensation before he begins the work on which he bases the claim. If the basis for the dispute does not become apparent until the contractor has proceeded with the work, and it is not practical or feasible to stop the work, the contractor will immediately inform the engineer that he will proceed with the work and that he will submit his written intent to claim within 24 hours. If proper notification is not given, and the engineer is not afforded proper facilities by the contractor for keeping strict account of the actual cost as required, then the contractor hereby agrees to waive any claim for such additional compensation. Such notice by the contractor, and the fact that the engineer has kept account of the cost as aforesaid, shall not in any way be construed as proving or substantiating the validity of the claim.

In the event a contractor has submitted a claim meeting the requirements outlined herein, the contractor shall make his records available for technical and audit evaluation after the work has been performed. Should the findings of the technical and audit evaluation differ substantially from the claim, these differences shall be resolved before further processing of the claim. If the contractor fails to make his records available for evaluation no further action toward resolution of the dispute will be considered by the Department. If the claim is found acceptable it will be resolved on the basis of equitable adjustment from contractor's actual records of costs for materials and supplies, labor, equipment hours, overhead and indirect costs; and may include applicable reasonable profit or loss. The actual hourly cost of equipment used in the work is not to be construed as the Montana Department of Highways' booklet for equipment rental rates.

SECTION 6

CONTROL OF MATERIAL

06.01 SOURCE OF SUPPLY AND QUALITY REQUIREMENTS. All materials which are to be used on or incorporated into a project shall meet the requirements of the specifications and be approved by the engineer. Attention is directed to section 20 concerning the sampling and testing of surfacing aggregates. The material, at the source of supply, is subject to the engineer's approval before delivery of said materials onto the project. All materials are subject to inspection and possible rejection at any time prior to their incorporation in the project. An approved source of supply remains approved only so long as the materials obtained therefrom are acceptable. The Department will not be responsible for the quality or quantity of materials produced at or developed from any source; when quality and quantity are shown at all it will be an indication only, unless specifically stipulated otherwise. The engineer has the authority to reject any part of the materials at a source. If the contractor becomes delinquent in payments due the owner of any source of materials, and said owner duly and properly notifies the Department of such circumstances, then such delinquent payments may be withheld from estimate payments due the contractor.

06.02 LOCAL MATERIAL SOURCES.

(A) General: Local materials refer to and include aggregate materials used in the surfacing structure as well as earth and rock materials used as "borrow" for roadway or other embankments.

Material sources are of the following types: Indicated sources, Contractor furnished sources, mandatory sources.

When material deposits are not indicated on the plans or described in the Special Provisions, the contractor shall provide sources of material acceptable to the engineer.

No bidder shall acquire privately owned sources for his exclusive use, excepting sources owned by a bidder under a recorded long-standing title.

Unless otherwise permitted, pits and quarries shall be so excavated that water will not collect and stand therein.

(B) Indicated Sources. Possible sources of local materials may be indicated on the plans and described in the special provisions. The quality

of material in such deposits will be acceptable in general, but the contractor shall determine for himself the amount of equipment and work required to produce a material meeting the specifications. It shall be understood that it is not feasible to ascertain from samples the limits for an entire deposit and that variations shall be considered as usual and are to be expected. The engineer may order procurement of material from any portion of a deposit and may reject portions of the deposit as unacceptable.

Whenever the "Available Surfacing Materials Report" shows the source to be "Department Optioned" the materials from such source or sources will be available, for that project, to the contractor at no cost or royalty unless specifically stated otherwise in the special provisions.

Where the Department has made arrangements with the owners of the land in the vicinity of a project for the sampling of material from an owner's property, such arrangements are made solely for the purpose of providing all bidders an equal opportunity to obtain material from such property.

The Department may acquire and make available to the contractor, the use of such property as may be specified, for plant sites, stockpiles and haul roads. Contractors may, upon written request, inspect the documents evidencing such arrangements between property owners and the Department. The Contractor shall adhere to all agreement stipulations including but not limited to smoothing of pits, conservation and replacement of topsoil, seeding, repair or obliteration of haul roads, cattleguards and fencing, and if provided, pay all royalties involved.

A reclamation plan pertaining to Indicated Sources shall be furnished by the contractor and shall meet the requirements of Article 06.02(E) - Reclamation Requirements.

Payment to complete the agreement stipulations will be subsidiary to other contract items, unless otherwise stipulated on the plans.

(C) Contractor Furnished Sources. If the contractor desires to use materials from sources other than those indicated, with the exception of Unclassified or Special Borrow, he shall acquire the necessary rights to take materials from the sources and shall pay all costs related thereto, including any which may result from an increase in length of haul. All costs of exploring and developing such other sources shall be borne by the contractor. The use of material from other than indicated sources will not be permitted until representative samples taken by the engineer have been approved and written authority is issued for the use thereof. Unclassified or Special Borrow Excavation shall be treated in accordance with the provisions of Article 11.02(B).

When sources of material or material deposits are provided by the contractor, the Department will assume the cost of processing samples to determine the suitability of the material. Borrow and gravel sources or waste areas shall be selected by the contractor and approved by the engineer, prior to obtaining materials therefrom or depositing materials thereon.

In general, approval will be given only to those areas which after completion, harmonize with the landscape and harbor no conditions incompatible to the various surrounding life forms.

A reclamation plan pertaining to Contractor Furnished Sources shall be furnished by the contractor and shall meet the requirements of Article 06.02(E) - Reclamation Requirements.

(D) Mandatory Material Sources. The Department may, under certain circumstances, designate a mandatory source or sources of material which will mean that the contractor is required as a condition upon which he prepares his bid for the project, and further will be a condition of the contract, to obtain materials for the project from such mandatory sources. Conditions for producing materials from a mandatory source shall be found in the special provisions.

A reclamation plan pertaining to Mandatory Material Sources shall be furnished by the contractor and shall meet the requirements of Article 06.02(E) - Reclamation Requirements.

(E) Reclamation Requirements. All reclamation provisions apply to mandatory material sources, indicated sources, contractor furnished sources or any such sources, whether procured in contractor dealings with landowners, or whether state optioned.

The contractor shall familiarize himself with the requirements of the Montana Open Cut Mining Act (Chapter 326, Session Laws of 1973), the Hard Rock Mining Act (Chapter 252, Session Laws of 1971), the Montana Water Pollution Act (Chapter 22, Session Laws of 1971), and shall be in conformance with the requirements thereof.

Prior to commencing operations for the removal of any earth, quarried rock, sand, gravel aggregate or other substance from material sources outside of the highway rights-of-way, the contractor shall have submitted a reclamation plan to, and received approval of the plan from, the Montana Department of Highways. Reclamation shall be accomplished in conformance with the approved reclamation plan as soon as possible after completion of removal operations. Changes are permissible to an approved plan if such changes are in accord with the minimum requirements of this specification and granted prior to completion of work.

Approval of the reclamation plan will be based on the overall effect of the finished slopes on the adjacent landscape, the location of the pit relative to the view from the traveled roadway, possible adverse effect on streams, lakes, ground water and adjacent vegetation and surrounding environment. No sand or gravel pits shall be located in any flowing stream nor shall excavation be made on any stream floodway at locations likely to offer a new channel to the stream at times of flooding. The contractor shall take all necessary precautions for the protection of the general public and the safety of the persons and their property adjacent to the work.

The contractor shall submit a plan of his **intended** operation and the method and manner of reclamation that will be used as follows:

1. Prior to commencing any operation for the removal of any quarry rock, sand, gravel or earth, the contractor is to complete a reclamation report form furnished him at the Preconstruction Conference, and submit it to the Project Manager as his plan of reclamation for the lands disturbed by such operation. This reclamation plan shall contain as a minimum the following information:

- A. Project number and designation for each pit that will be opened.
- B. Legal description (subdivision, section, township and range), acreage and a plat of the surface area to be disturbed.
- C. Name and address of surface owner or owners.
- D. Name of contractor actually conducting operations (Prime or sub).
- E. Current use of area to be disturbed and of immediate surrounding area.
- F. Type or types of vegetation present.
- G. Depth to water table at times of high and low water table conditions.
- H. Information on soil type.
- I. Proposed use for reclaimed land.

A map or maps drawn to scale showing the following: (Items J thru Q)

- J. Location of surface water on or near the site, natural drainage and final proposed drainage.
- K. Location of access, haul and support roads and anticipated handling of these after removal is complete.
- L. Location of man-made or natural obstructions, such as buildings, utility transmission lines, wells, streams, etc. and the contemplated reclamation handling thereof.
- M. Location of proposed dams, diversion structures and settling basins, if required.

N. Location of treatment, screening, washing, crushing and sorting plants.

O. Location of area where waste will be disposed of or buried.

P. Outline of area where topsoil material will be replaced.

Q. Outline of intended vegetation area and proposed species to be established.

R. A contour grading plan showing the intended finished shape of the area shall be provided, **or** a sketch showing; topographic features, anticipated slopes, grading depths, drainage and other pertinent data necessary to indicate his **intended** operation and the **intended** appearance of the finished pit.

S. A plan to protect the newly-seeded areas from grazing pressure until the vegetative cover is established. Temporary fencing as specified in Standard Specification Article 81.04 may be required as the situation dictates. Cost of erecting, maintaining and removing the temporary fence to be borne by the contractor and absorbed in the unit price of other items.

2. In addition to the requirements of one above, the contractor shall shape, slope (recommended maximum 3:1 but in any event, pit walls remaining shall blend with natural slope of the adjacent area), revegetate, place top soil on, or in other ways provide a finished materials pit site that blends satisfactorily with the adjacent landscape and is acceptable in appearance to the engineer.

Unless directed otherwise, overburden, including topsoil, shall be stripped from all material sources and conserved. After the pit or excavated area has been completed and all materials needed therefrom removed, the sides shall be shaped, trimmed and sloped as required. Topsoil material and overburden shall be placed back in the pit area. The entire excavated area including haul roads shall be seeded and fertilized at the rates and between the dates indicated on the plan or as shown in the Special Provisions or as directed.

3. Each landowner with whom the contractor has dealt for material sources must be informed and accept the above requirements. The landowner shall acknowledge his acceptance of the reclamation plan by signing the report form (CSN40A) prior to submittal of the reclamation plan to the Department of Highways for approval.

4. All work herein specified in removing and replacing topsoil, seeding and fertilizing will be measured and paid for as follows:

DEPARTMENT OPTIONED SOURCES: Topsoil shall be measured in accordance with Article 11.03(A) Grading, Seeding and Fertilizing shall be

measured in accordance with Article 17.14. Payment for Topsoil, Seeding and Fertilizing will be the contract unit price for these items.

CONTRACTOR FURNISHED SOURCES: Topsoil, Seeding and Fertilizing will not be measured, nor paid for separately, but will be considered to be part of, and absorbed in, the unit prices for other contract items.

(F) Protection of Livestock & Property. The contractor, his agents and employees, together with their machinery and equipment shall take the necessary precautionary measures to preclude the straying of livestock into or out of any source of materials and access thereto.

The contractor shall be obligated to respect and protect all irrigation facilities. Damage resulting from his operation shall be promptly repaired or replaced to the landowners satisfaction.

(G) Rejects. Material referred to as "rejects" is generally an excess of fine materials - either inherent in a rock pit, gravel pit or quarry or one accumulated during crushing and screening operation. Unacceptable rejects shall be disposed of as directed by the engineer. When desired, acceptable rejects shall be stockpiled at a site selected or approved by the engineer, as follows:

(1) When a source of material is optioned by the Department for use by the contractor, and the contractor uses materials therefrom, the Department will retain title to all rejects, screenings or other by-products resulting from the development of the material site. The contractor will not receive compensation for accepted rejects placed in stockpile - other than 15 cents per ton mile for haul in excess of 200 feet from the crusher site.

(2) When a source of material is optioned by the contractor, he will receive compensation for acceptable rejects placed in stockpile as follows: An allowance equal to the royalty per cubic yard for the material removed and 15 cents per ton mile for haul in excess of 200 feet from the crusher site.

06.03 SAMPLES, TESTS, CITED SPECIFICATIONS. All materials will be inspected, tested and accepted by the engineer before incorporation in the work. Work in which untested and unaccepted materials are used without approval or written permission of the engineer shall be performed at the Contractor's risk and may be considered as unacceptable and unauthorized and will not be paid for. Unless otherwise designated, when a reference is made in these specifications to a specification or test designation either of AASHTO, ASTM, Federal Specifications, or any other recognized nonproprietary national organization. It shall mean the

specification or test method (including Interim AASHTO and Tentative ASTM) which is current on the date of advertisement for bids, and as amended by the Department of Highways Test Methods Manual insofar as covered therein. Copies of individual Montana test methods are available at the Montana Department of Highways headquarters testing laboratory in Helena and will be furnished to interested persons upon request.

When required by the engineer or requested by the contractor, representative preliminary samples of the character and quantity prescribed shall be submitted for examination and shall be tested in accordance with the methods referred to herein. The acceptance of a preliminary sample shall not be construed as acceptance of materials. Only the materials actually delivered for incorporation in the project will be considered and their acceptance or rejection will be based solely on the results of the test prescribed in the specifications.

Crushing and screening plants shall be equipped with approved sampling equipment operable from the ground or a platform. The sampling device shall be constructed and operated so that it will move at a constant rate across the full width of the falling column of material from the discharge belt or chute. The sampling equipment shall be constructed so that a representative sample can be taken and conveyed to the ground by means of a slide, chute, or similar means where the sampled material can be safely and conveniently collected.

06.04 PLANT INSPECTION. The engineer may undertake the inspection of materials at the source.

In the event plant inspection is undertaken the following conditions shall be met:

(A) The engineer shall have the cooperation and assistance of the contractor and the producer with whom he has contracted for materials.

(B) The engineer will have full entry at all times to such parts of the plant as may concern the manufacture or production of the materials being furnished.

(C) The material producer shall furnish, free of charge, all reasonable facilities to assist in determining whether the material furnished meets with the requirements of the specifications.

(D) Adequate safety measures shall be provided and maintained.

(E) The contractor shall give sufficient notification of the placing of orders for materials to permit testing.

It is understood that the Department reserves the right to retest all

materials prior to incorporation into the work which have been tested and accepted at the source of supply after the same have been delivered, to reject all materials which, when retested, do not meet the requirements of these specifications, or those established for the specific project.

06.05 FIELD LABORATORY. The Department will furnish all field offices and laboratories unless otherwise specified.

The contractor shall, when requested by the engineer, furnish at no cost to the Department, 110-120 volt alternating current of sufficient capacity and an adequate water supply to simultaneously operate all testing equipment for the offices and laboratories, whether furnished by him or the Department.

06.06 STORAGE OF MATERIALS. Materials shall be so stored as to assure the preservation of their quality and fitness for the work. Stored materials, even though approved before storage, may again be inspected prior to use in the work. Stored materials shall be located so as to facilitate their prompt inspection. Approved portions of the right-of-way may be used for storage purposes and for the placing of the contractors' plant and equipment, but any additional space required therefore must be provided by the contractor at his expense. Private property shall not be used for storage purposes without obtaining written permission of the owner or lessee, and if requested by the engineer copies of such written permission shall be furnished him. All storage sites shall be restored to their original condition by the contractor at his expense. This shall not apply to the stripping and storing of topsoil, or to other materials salvaged from the work.

06.07 HANDLING MATERIALS. All materials shall be handled in such a manner as to preserve their quality and fitness for the work. Aggregates shall be transported from the storage site to the work in tight vehicles so constructed as to prevent loss or segregation of materials after loading and measuring in order that there may be no inconsistencies in the quantities of materials intended for incorporation in the work as loaded, and the quantities as actually received at the place of operations.

06.08 UNACCEPTABLE MATERIALS. All materials not meeting the requirements of the specifications at the time they are used will be accepted or rejected in conformity with provisions of Article 05.03.

06.09 COMMISSION FURNISHED MATERIAL. The contractor shall furnish all materials required to complete the work, except those specified to be furnished by the department.

Material furnished by the Department will be delivered or made available to the contractor at the points specified in the special provisions.

The cost of handling and placing all materials after they are made available to the contractor shall be considered as included in the contract price for the item in connection with which they are used.

The contractor will be held responsible for all material made available to him, and deductions will be made from any monies due him to make good shortages and deficiencies, from any cause whatsoever, and for damage which may occur after such delivery, and for any demurrage charges.

06.10 AMERICAN-MADE MATERIALS. American-Made highway and bridge construction materials shall be used by the contractor unless otherwise authorized in writing by the Director of Highways.

This image shows a full page of white paper with horizontal blue or grey ruling lines. The lines are evenly spaced and run across the width of the page, typical of notebook paper. There is no handwriting or other markings on the page.

SECTION 7

LEGAL RELATIONS AND RESPONSIBILITY TO THE PUBLIC

07.01 LAWS TO BE OBSERVED. The contractor shall keep fully informed of all Federal and State laws, all local laws, ordinances, and regulations, and all orders and decrees of bodies or tribunals having any jurisdiction or authority, which in any manner affect those engaged or employed in the work, or which in any way affect the conduct of the work. The contractor shall at all times observe and comply with all such laws, ordinances, regulations, orders, and decrees; and shall protect and indemnify the Department and its representatives against any claim or liability arising from or based on the violation of any such law, ordinance, regulation, order, or decree, whether by himself or his employees.

A plea of misunderstanding due to ignorance of the law will not be considered. If the bidder or contractor shall discover any provision in the contract which is contrary to or inconsistent with any law, by-law, ordinance or regulation he shall forthwith report it in writing to the Department.

He shall be governed by and comply with statutes regulating the hours of employment on public works.

The contractor shall comply with the requirements of the Occupational Safety and Health Act (OSHA) Regulations for Construction as published in the Federal Register April 17, 1971 and any subsequent amendments or additions thereto.

The cost of all materials, tools, equipment and labor necessary and incidental to meet the requirements of the safety standards will not be paid for directly but will be included in the contract unit prices for the various other items of work unless otherwise specified.

07.02 PERMITS, LICENSES AND TAXES. The contractor shall procure all legally required permits and licenses, pay all charges, fees, and taxes, and give all notices necessary and incidental to the due and lawful prosecution of the work.

07.03 PATENTED DEVICES, MATERIALS AND PROCESSES. If the contractor uses any design, device, material, or process covered by letter or patent or copyright, he shall provide for such use by suitable legal

agreement with the patentee or owner. The contractor and the surety shall indemnify and save harmless the Department, any affected third party, or political subdivision from any and all claims for infringement by reason of the use of any such patented design, device, material or process, or trademark or copyright, and shall indemnify the Department for all costs, expenses, and damages which it may be obliged to pay by reason of an infringement, at any time during the prosecution or after the completion of the work.

07.04 RESTORATION OF SURFACES OPENED BY PERMIT. The right to construct or reconstruct a utility facility in the highway or street or to grant permits for same, at any time, is hereby expressly reserved by the Department for the proper authorities of the municipality in which the work is done. The contractor shall not be entitled to damages either for the digging up of the street or for delay occasioned thereby. Any individual, firm or corporation wishing to make an opening in the highway must secure a permit from, and will be required to deposit security with, the Department in a suitable amount to cover the cost of making necessary repairs and the contractor shall not allow any person or persons to make an opening unless duly authorized by the engineer. The contractor shall allow parties bearing such permits, and only those parties, to make openings in the highway. When ordered by the engineer, the contractor shall make in an acceptable manner all necessary repairs due to such openings and such necessary work will be paid for as extra work, or as provided in these specifications, and will be subject to the same conditions as for the original work.

07.05 FEDERAL AID PROVISIONS. When the United States Government pays all or any portion of the cost of a project, the Federal laws and the rules and regulations made pursuant to such laws must be observed by the contractor, and the work shall be subject to the inspection of the appropriate Federal agency.

Such inspection shall in no sense make the Federal Government a party to this contract and will in no way interfere with the rights of either party hereunder.

07.06 SANITARY PROVISIONS. The contractor shall provide and maintain in a neat, sanitary condition such accommodations for the use of his employees as may be necessary to comply with the requirements of State and local Boards of Health, or of other bodies or tribunals having jurisdiction.

07.07 PUBLIC CONVENIENCE AND SAFETY. The contractor shall at all times so conduct his work as to assure the least possible obstruction to traffic. The safety and convenience of the general public and the residents along the highway and the protection of persons and property shall be provided for by the contractor including, but not limited to, such items as specified in Article 04.04.

No road shall be closed to the public except by the express permission of the engineer.

07.08 RAILWAY-HIGHWAY PROVISIONS. All work performed by the contractor or his subcontractor on railroad right-of-way shall be performed at such times and in such manner so as not to necessarily interfere with the movements of trains or traffic upon the property of the railway company.

The contractor shall give sufficient advance notice, determined by agreement between the contractor and railway officials, to the railway company before starting operations on their property, hauling across their tracks, or blasting within 1000 feet of their property. The railway company shall be given advance notice of blasting further away than 1000 feet, when these operations may damage or delay railway property or services. The railway shall furnish the necessary flagging service, when required for the safe operation of their trains, with their forces under their rules and labor regulations.

The Department will reimburse the railway company direct for approved costs incurred for flagging service by the railway forces up to the estimated amount set forth in the contract, at no cost to the contractor.

All costs above the estimated amount shall be the contractor's obligation and will be deducted from any monies due or which may become due the contractor.

When no amount has been set forth in the contract for costs incurred for flagging services by railway forces, the contractor shall be responsible for all costs incurred. Flagging costs so incurred for the contractor's operations on or near railway property, hauling across railway tracks or blasting operations near railway property will be paid by the Department and deducted from any monies due or which may become due the contractor.

The contractor is cautioned to observe the requirements of Articles 07.10 and 07.18 when blasting or performing other work on or near railway property. The Department will enter into a three-party agreement with the contractor and railway officials, when required by the railway company.

If the plans or special provisions require that materials be hauled across

the tracks of a railway, the Department may make arrangement with the railway company for any new crossings required. If the contractor elects to haul over a crossing of his choice or if the plans or special provisions do not provide specified crossings then the contractor, or his subcontractor, shall make his own arrangements with the railway company for any crossings of their tracks and shall not in any manner legally obligate the Department or its agents.

Temporary crossings, requested by the contractor, shall be constructed, protected, maintained and removed by the railway company and the entire cost shall be borne by the contractor based on billings submitted by the railway company. Except for temporary crossings or existing open public grade crossings, the contractor shall not at any time cross the railway right-of-way or tracks with vehicles or equipment of any type or character. The contractor shall furnish insurance for operations performed by him or by subcontractors or both in the amount and kind set forth in Article 07.15 or by the special provisions.

07.09 LOAD RESTRICTIONS. The contractor shall comply with all legal load restrictions in the hauling of material on public roads beyond the limits of the project and across bridges within the project limits. A special permit will not relieve the contractor of liability for damage which may result from the moving of equipment.

The operation of equipment of such weight or so loaded as to cause damage to structures or the roadway or to any other type of construction will not be permitted. Hauling of materials over the base course or surface course under construction will be limited as directed. No loads will be permitted on a concrete pavement, base or structure before the expiration of the curing period.

The contractor shall be responsible for all damage done by his hauling equipment.

07.10 USE OF EXPLOSIVES. The contractor shall exercise the utmost care, in the use of explosives, not to endanger life, or property and he shall be responsible for all damages resulting from the use of explosives. Where no local laws or ordinances apply, storage shall be provided satisfactory to the engineer.

Explosives shall not be stored closer than 1000 feet from a road, building, camping area, or place of human occupancy, unless otherwise authorized.

All explosives shall be securely stored in a manner which complies with all laws and ordinances, and all such storage places shall be clearly marked. Only persons experienced in the handling of explosives shall be

allowed to use them on the project, and no shot shall be fired until warning has been sounded and all persons removed from the radius of danger. The number or intensity of charges shall be reduced whenever directed.

The contractor shall notify property owners, each railway company and each public utility company having facilities near the blasting area of his intentions to use explosives. Such notice shall be given sufficiently in advance to enable the companies to take precautions as they may deem necessary to protect their property from injury. The Department will in no way be responsible for non-compliance therewith or for damages to property or injury to persons resulting from accidental or premature explosion or from damage attributable to the use of such explosives.

07.11 PROTECTION AND RESTORATION OF PROPERTY AND LANDSCAPE. The contractor shall be responsible for the preservation of all public and private property. All land monuments and property marks shall be protected from disturbance or damage until the engineer has witnessed or referenced their location.

The contractor shall be responsible, until the contract is accepted for, all damage or injury to property resulting from any act, omission, neglect, misconduct, defective work or materials or from his manner or method of executing work.

The contractor shall replace or restore damaged or injured property, to a condition similar or equal to that existing before such damage or injury was done, at no cost to the Department.

07.12 EROSION, WATER POLLUTION — SILTATION CONTROL The contractor shall exercise every reasonable precaution throughout the life of the project to prevent pollution and siltation of rivers, streams or impoundments. Pollutants such as chemicals, fuels, lubricants, bitumens, raw sewage and other harmful wastes shall not be discharged into or alongside of rivers, streams, impoundments or into natural or manmade channels leading thereto. In addition, the Contractor shall conduct and schedule his operations to avoid muddying or silting of rivers, streams or impoundments. The contractor shall meet the requirements of the applicable regulations of the Department of Fish & Game, Department of Health and Environmental Sciences and other State or Federal regulations relating to the prevention or abatement of water pollution and siltation. The contractor's specific attention is directed to the Montana Water Pollution Control Act and the Montana Stream Preservation Act.

The contractor shall dispose of all refuse and discarded materials in an approved location.

Water pollution and siltation control work shall consist of temporary erosion control measures which may be shown on the plans, specified in the Special Provisions, proposed by the contractor and approved by the engineer, or ordered by the engineer during the life of the contract. Said work is intended to provide prevention, control and abatement of water pollution and siltation within the limits of the project and to minimize damage to the work and to adjacent property and streams or other bodies of water.

The contractor shall coordinate temporary pollution and siltation control work with permanent drainage and erosion control work and all other work on the contract, including permanent seeding that may be specified in the contract or ordered by the engineer to the extent practicable to assure that effective and continuous erosion control is maintained during the construction of the project.

The contractor shall provide temporary pollution and siltation control measures, including but not limited to the following:

Construct ditches, berms, culverts, etc. to control surface water.

Construct dams, settling basins, energy dissipators, etc. to control downstream flows.

Provide means of controlling underground water which may be encountered during construction.

Protect slopes by covering or by other means until permanent erosion control measures are effective.

Before starting any work on the project, the contractor shall submit to the engineer for acceptance a program for effective control of water pollution and siltation. Such program shall show the schedule for the erosion control work included in the contract and for all temporary water pollution and siltation control measures which the contractor proposes to take in connection with construction of the project to minimize the effects of his operations upon adjacent streams and other bodies of water. The contractor shall not perform any clearing and grubbing or earthwork on the project, other than that specifically authorized in writing by the engineer, until such program has been accepted. The contractor shall revise and bring up to date said water pollution control program at any time the engineer makes written request for revision.

In erodible soils, and where conditions permit, clearing and grubbing operations should be so scheduled and performed that grading operations and permanent erosion control features can follow immediately. Otherwise temporary erosion control measures shall be required between successive construction stages. Under no conditions shall the surface area

of erodible earth material exposed at one time by clearing and grubbing exceed 750,000 square feet without written approval by the engineer.

The engineer will limit the area of excavation, borrow and embankment operations in progress commensurate with the contractor's capability and progress in keeping the finish grading, topsoiling, permanent seeding and other permanent pollution and siltation control measures current in accordance with the contractor's approved water pollution and siltation control plans.

Slopes and areas finished in the winter and spring shall be permanently seeded before the end of the spring seeding period or as soon thereafter as conditions permit. Slopes and areas finished during the summer and early fall shall be permanently seeded during the fall seeding period unless otherwise specified.

The permanent seeding dates shall be as specified in the Seeding Special provisions attached to the contract.

Permanent seeding of the finished slopes during the specified spring and fall seeding periods will require frequent seeding operations and shall not be construed to mean that the required finishing, topsoiling, fertilizing, mulching, permanent erosion control placement and seeding can be done at the convenience of the contractor but shall be done as the slopes are finished. Any additional move-in required will not be paid for separately as the cost thereof shall be absorbed in the contract unit price for the various seeding, fertilizing, mulching and mobilization items.

Should seasonal limitations make such coordination unrealistic, temporary erosion control measures shall be taken immediately to the extent feasible and justified. Under no conditions shall the amount of surface area or erodible earth material exposed at one time by excavation, borrow or fill within the right-of-way exceed 750,000 square feet without written approval of the engineer.

The engineer may increase or decrease the amount of surface area of erodible earth material to be exposed at one time by clearing and grubbing, excavation, borrow and fill operations as determined by his analysis of project conditions.

The limitation on the two operations is to be considered separate. The maximum area that can be underway at one time is 750,000 square feet of clearing and grubbing and 750,000 square feet of grading, unless modified in the contract or by the engineer.

The engineer may modify the 750,000 square feet limitation when project conditions such as soil characteristics or contractor operations or both indicate that a smaller or larger area is reasonable. On a long or complex project, the contractor may have several separate grading

spreads or subcontractors in operation in which case it may be reasonable in some instances to apply the limit to each individual operation assuming finishing, mulching, seeding, etc. is closely following the rough grading operations in each instance. In these cases the specified pollution control procedures shall be applied to each individual operation.

Where erosion damage is probable due to the nature of the material or the season of the year, the contractor's operations shall be so scheduled that permanent erosion control features will be installed concurrently with or immediately following grading operations.

In the event that a suspension of work is ordered for an extended period of time, in accordance with Article 08.03, the contractor shall take all action necessary to control erosion, siltation, pollution and run-off during the shutdown period before the Department will assume responsibility for maintenance. The Department's responsibility will be as set forth in Article 04.04 (C) (3) of the Standard Specification.

When the temporary control facilities are no longer needed, they shall be removed and the areas finished as directed by the engineer.

Temporary water pollution control measures will be measured by the respective unit for material and work performed in accordance with the contractor's approved plan or as directed by the engineer or both.

Payment for temporary water pollution and siltation control, measured as provided above, will be at agreed prices or on a force account basis or both. The number of units in dollars set down in the contract is an estimated amount only, which may be adjusted up or down by the Engineer in accordance with the needs of the project.

If temporary water pollution and siltation control measures are required due to the contractor's negligence, carelessness, or failure to install permanent controls as a part of a practical work schedule, and are ordered by the engineer, such work shall be performed by the contractor at no cost to the Department.

In case of failure on the part of the contractor to control erosion, pollution and/or siltation, the engineer reserves the right to employ outside assistance or to use his own forces to provide the necessary corrective measures. Such incurred direct costs will be charged to the contractor and appropriate deductions made from the contractor's monthly progress estimate.

Maintenance of temporary pollution, siltation or erosion controls or removal of such installed controls if directed, will be paid for on a force account basis.

Erosion control items which are a part of the contract shall be considered as permanent control measures and payment will be made at the unit contract prices involved.

Should seeding during the times specified fail to establish an acceptable stand of grass, the areas where failure has occurred shall be reconditioned, remulched, refertilized and reseeded in accordance with Section 17.

Payment for required seedbed remulching, refertilizing, reconditioning and reseeding will be at the unit prices bid for the various items of work.

07.13 SMOKE AND DUST CONTROL. Whenever a hot-mix paving plant, aggregate crusher or similar operation is to be conducted, the contractor shall acquaint himself with all local conditions, city, county and state laws pertinent to air pollution before commencing his operations. It is possible that legal action may be instituted against the contractor to force him to conduct his operation in a dust and smoke free manner. The contractor should be prepared to operate in a manner satisfactory to a restraining court order. This may mean employing adequate dust filters and smoke collectors or use of other means meeting the existing requirements. No additional payment will be made to the contractor for the use or installation of dust or smoke control devices nor for the disruption of work or loss of time occasioned by the installation of such control devices, or for any other related reasons.

The contractor shall have informed himself of all applicable Department of Health and Environmental Sciences requirements and similar State or Federal requirements, pertaining to control of or abatement of air pollution. He shall have provided or be prepared to provide such air pollution control measures as are required to comply with the minimum standards established by such agencies.

07.14 FOREST PROTECTION. The contractor shall meet the requirements of all regulations of the authority, having jurisdiction, governing the protection of forests and parks and the carrying out of work within or adjacent to State or National forests and parks. All sanitary laws and regulations, with respect to the performance of work in forest areas shall be observed. The areas shall be kept in an orderly condition. All refuse shall be disposed of and permits obtained for the construction and maintenance of construction camps, stores, warehouses, residences, latrines, cesspools, septic tanks, and other structures.

All reasonable precaution shall be taken by the contractor and his sub-contractors to prevent, suppress and to assist in preventing and suppressing forest fires. Every possible effort shall be made to notify a forest official at the earliest possible moment of the location and extent of any fire seen by them.

During the period from April 1st to November 15th of each year, spark arresters satisfactory to the forest supervisor in charge of the area concerned shall be maintained on all steam and gas driven machinery used on the project and on all flues at construction camps.

07.15 INSURANCE REQUIREMENTS.

(A) Insurance on All Contracts. The contractor shall carry public liability and property damage insurance to indemnify the public for injuries and damages sustained by reason of the prosecution of the work.

The public liability insurance shall be in the amount of at least \$250,000 dollars for each person and a total of \$500,000 dollars for each occurrence. The property damage shall be in the amount of at least \$250,000 dollars for one occurrence and \$500,000 dollars in the aggregate. Work shall not be started until the contractor has submitted evidence to the Department that he has adequate insurance.

(B) Insurance Involving Railroad and Railways. On contracts involving work on or near railroad property the contractor shall, when required in the Special Provisions, purchase on behalf of the railroad, Railroad Protective Liability Insurance. The limits of liability will be set forth in the special provisions.

The policy form representative of the type of insurance required in conjunction with work on or near railroad property is set forth in the U.S. Department of Transportation's FHPM 6-6-2-2. Use of this form is required for all applicable projects and will be included in and made part of the contract.

Copies of the insurance policy required above plus the insurance policy required by Article 07.15 (A) shall be delivered to and approved by the railroad company prior to the entry upon or use of the railroad property by the contractor.

(C) Insurance On Contracts Involving Utility Property and Services. See Article 07.18 for additional insurance which may be required on contracts involving property and services.

(D) General. The insurance policies carried by the contractor shall be endorsed to the effect that no policy shall be cancelled, altered, or amended or coverage reduced without the giving of not less than 30 days written notice by the Insurance Company to the insured and the Department. The required insurance shall be kept in full force and effect until all work required to be performed shall have been satisfactorily completed and accepted in accordance with the terms of the contract. All

insurance policies issued in connection with the contract must be countersigned by a Montana Resident Agent.

(E) Third-Party Beneficiary Claims. It is specifically agreed between the parties executing this contract that it is not intended by any of the provisions of any part of the contract to create the public or any member thereof a third-party beneficiary hereunder, or to authorize anyone not a party to this contract to maintain a suit for personal injuries or property damage pursuant to the terms or provisions of this contract.

07.16 OPENING SECTIONS OF PROJECT TO TRAFFIC. At the option of the engineer, certain sections of the work may be opened for traffic. Such opening shall not constitute acceptance of the work, or any part thereof, or a waiver of any provisions of the contract.

Necessary repairs or renewals made on sections of roadway opened, due to defective materials or work or to cause other than ordinary wear and tear, pending completion and acceptance of the roadway, shall be covered by Article 07.17.

If the contractor is dilatory in completing shoulders, drainage structures, or other features of the work, the engineer may order all or a portion of the project open to traffic, but in such event the contractor shall not be relieved of his liability and responsibility during the period the work is opened prior to final acceptance. The contractor shall conduct the remainder of his construction operations so as to cause the least obstruction to traffic.

07.17 CONTRACTOR'S RESPONSIBILITY FOR WORK.

Until final acceptance of the work under the contract, the contractor shall have the charge and care thereof and shall take every care and precaution against loss, injury or damage to any part thereof by the elements, by traffic or from any other cause, including but not limited to fire, theft, pilferage, vandalism or third party negligence whether arising from the execution or from the nonexecution of the work or otherwise. The contractor shall rebuild, repair, restore, and make good all injuries or damages to any portion of the work occasioned by any of the above causes before final acceptance and shall bear the expense thereof except damage to the work due to unforeseeable causes beyond the control of and without the fault or negligence of the contractor, including but not restricted to acts of God such as earthquake, flood, tornado, or other cataclysmic phenomenon of nature or acts of the public enemy or of governmental authorities.

Contractors shall be governed by their judgment of the probable weather and stream flow conditions. The cost of loss, injury or damage of any nature occurring to such work facilities as dikes, cofferdams, caissons, work bridges, haul bridges, and the like, shall be the responsibility of the contractor.

The Department will assume the responsibility for installed delineators, impact attenuators, median barrier, guard rail, guide posts, light poles, sign supports, and the like which are to become part of the work, but have been damaged as a direct result of public traffic. The Department will also assume the responsibility for any building that has been completed in its entirety, is fully functional, and is open to the public for the purpose for which it is intended, in compliance with contract special provisions or by order of the engineer, and which is damaged as a result of public use or vandalism.

Damage qualifying under the exceptions listed above shall be repaired promptly as ordered by the engineer, and compensation therefor shall be made at applicable contract unit prices. Should unit prices be determined by the Engineer as not being applicable, payment shall be made by agreed price or by force account. Where public safety is affected, the engineer may elect to accomplish repair by means of Department provided forces.

The acceptance by the State of responsibility for damages as above set forth shall be understood be acceptance only insofar as it relieves the contractor of responsibility for damages which are a result of public traffic, and will not entitle the contractor to release of any part of retained percentages, it will not relieve him from responsibility for defective workmanship or materials, and it will not constitute a waiver of any of the provisions of the contract.

The contractor shall, at all times, conduct his work to insure the greatest possible degree of uninterrupted convenience and safety to the general public and to property owners adjacent to the work. Access for adjacent property owners shall, at all times, be maintained.

In case of suspension of work from any cause whatever, the contractor shall be responsible for the project and shall take such precautions as may be necessary to prevent damage to the project, provide for normal drainage and shall erect any necessary temporary structures, signs, or other facilities at his expense.

07.18 CONTRACTOR'S RESPONSIBILITY FOR UTILITY PROPERTY AND SERVICES. At points where the contractor's operations are adjacent to utility or other property, damage to which might result in consider-

able expense, loss, or inconvenience, work shall not be commenced until all arrangements necessary for the protection thereof have been made. The contractor shall contact the owners of service or other facilities, or adjacent property, to determine what measures, if any, should be adopted to assure adequate protection of said facilities and to protect persons and property from any damage that might result. The contractor shall learn the locations of such facilities and properties, then mark and distinguish them. Extreme care shall be taken in excavating and backfilling adjacent to underground service lines or other types of underground facilities. When a project involves such circumstances, insurance of a comprehensive type, covering underground damage and occurrences resulting therefrom, shall be procured and carried, in addition to the insurance coverage required by the provisions of Article 07.15, "Insurance Requirements."

If it is necessary in the prosecution of the work, to interrupt existing surface drainage, sewers, or underdrainage, temporary drainage facilities shall be provided and maintained at the contractor's expense until permanent drainage facilities are completed. The contractor shall be responsible for, and shall take all necessary precautions to protect and preserve any and all existing tile drains, sewers, or other sub-surface drains, conduits and other underground structures or parts thereof, which may be affected by the operations in the contract, and which in the opinion of the engineer may be properly continued in use without any change.

In the event of interruption to water or utility services as a result of accidental breakage or as result of being exposed or unsupported, the contractor shall promptly notify the proper authority and shall cooperate with said authority in the restoration of service.

If water service is interrupted, repair work shall be continuous until the service is restored. No work shall be undertaken around fire hydrants until provisions for continued service have been approved by the local fire authority. The contractor shall at no cost to the Department satisfactorily repair all damage to such facilities or structures which may result from his operations or from his negligence during the period the contract is in force. The contractor and his surety shall be solely and directly responsible to the owners and operators of such properties for damage, injury, expense, loss, inconvenience or delay, or for any suits, actions, or claims of any character which may result from the carrying out of the work. The Commission may require the contractor to furnish Protective Public Liability and Property Damage insurance to each corporation, company partnership, or individual owning or operating the properties affected.

07.19 FURNISHING RIGHT-OF-WAY. All right-of-way for the roadway

shall be provided by the Department without cost to the contractor. All right-of-way may not have been obtained at the time bids are opened and the proposal considered. In this case the award may not be made until the entire right-of-way has been obtained. The submission of a bid will be construed as an acceptance of this condition by the bidder, and no claim for damage or loss of anticipated profits on account of unavoidable delay in securing right-of-way will be considered by the Department. If the contract is materially delayed because of right-of-way difficulties, due consideration will be given by the Department in extending the contract time to make proper allowances therefor.

07.20 PERSONAL LIABILITY OF PUBLIC OFFICIALS. In carrying out these specifications, or in exercising any power or authority granted to them by or within the scope of the contract, there shall be no liability upon the Commission, Department, engineer, or their authorized representatives, either personally or as officials of the State, it being understood that in all such matters they act solely as agents and representatives of the State.

07.21 NO WAIVER OF LEGAL RIGHTS. The Department will not be precluded or estopped by any measurement, estimate, or certificate made either before or after the completion and acceptance of the work and payment therefor, from showing the true amount and character of the work performed and materials furnished by the contractor, nor from showing that any such measurement, estimate or certificate is untrue or is incorrectly made, nor that the work or materials do not in fact conform to the contract. The Department will not be precluded or estopped, notwithstanding such measurement, estimate, or certificate and payment in accordance therewith, from recovering from the contractor or his sureties, or both, such damage as it may sustain by reason of his failure to comply with the terms of the contract. Neither the acceptance by the Department, or any representative of the Department, nor any payment for or acceptance of the whole or any part of the work, nor any extension of time, nor any possession taken by the Department, will operate as a waiver of any portion of the contract or of any power herein reserved, or of any right to damages. A waiver of any breach of the contract shall not be held to be a waiver of any other or subsequent breach.

SECTION 8

PROSECUTION AND PROGRESS

08.01 ASSIGNMENT OR SUBLETTING OF CONTRACT.

(A) Assignment of Contract. The contractor shall not assign more than 50 percent of his potential earnings, nor transfer, convey or otherwise dispose of his right, title or interest therein to any other person, firm or corporation without the written consent of his surety and of the Department of Highways.

(B) Subletting. The contractor shall perform with his own organization, and with the assistance of workmen under his immediate superintendence, work of a value not less than 50 percent of the combined value of all items of work covered by the contract, provided, that any work under the contract, which will require highly specialized knowledge, craftsmanship or equipment not ordinarily available in contracting organizations qualified to bid on the project, may be designated and shown in the advertised specifications as "Specialty Items". Specialty Items may be performed by subcontract without regard to the above limitation.

No portion of the contract shall be sublet, assigned or otherwise disposed of except with the written consent of the Department of Highways. Work under a subcontract shall not be started until the subcontract has been approved by the engineer. Requests for permission to sublet, assign or otherwise dispose of a portion of the contract shall be in writing and accompanied by a showing that the organization which will perform the work is particularly experienced and equipped for such work. The request also shall be accompanied by at least three executed and certified copies of the subcontract and a letter from the surety, directed to the Department of Highways, consenting to the subcontract.

Assignments by the prime contractor or a subcontractor of more work than the allowable 50 percent, and attempting to account for such additional labor, equipment and supervision costs on his own payroll records will be considered as subterfuge to circumvent the subcontracting provisions of the contract and are not allowable.

The contractor shall inform the subcontractor of all provisions of the contract, including labor and minimum wage rate provisions. The minimum wage for labor, as stated in his contract shall apply to labor performed on all work sublet, assigned or otherwise disposed of in any way.

All required provisions and predetermined minimum wage rates, applicable to the project, shall be physically attached to and made a part of the subcontract. The subcontract form shall contain these words "The subcontractor agrees to comply with all of the labor provisions in accordance with the attached 'Required Provisions' and 'Predetermined Minimum Wage Rates'."

All subcontractors are agents of the contractor. The contractor shall be responsible for all work, material furnished and any indebtedness incurred by the subcontractor. A subcontract may be terminated by the engineer in accordance with the provisions of Articles 05.01 and 05.12, if the subcontractor does not perform satisfactory work.

Written consent to sublet, or transfer the contract, shall not release the contractor of his liability under the contract and bond.

All subcontractors shall be prequalified under regulations of Article 02.01.

(C) Equipment Rental. When it is contemplated that additional equipment, not owned or under a rental purchase agreement, will be used by the contractor or subcontractor, and such use is to be paid for on an equipment rental basis, notification in writing shall be submitted to the engineer, prior to use of the equipment. The subcontractor or subcontractor, as the case may be, shall include the operators of such equipment on their respective payrolls at a rate not less than those set forth in the predetermined minimum wage rates.

The contractor or subcontractor shall assume the payment for and the reporting of all contractual diesel fuel obligations that may have been made a part of the equipment rental contract.

08.02 NOTICE TO PROCEED. The "Notice to Proceed" will stipulate the date on which it is expected the contractor will begin the construction and from which date contract time will be charged. This date will be 20 calendar days after completion of contract award procedures. In the event the 21st day falls on a Saturday, Sunday, or holiday, the proceed date shall be the Monday after a weekend, or the workday following a holiday.

08.03 PROSECUTION OF WORK. It is agreed and understood that the contractor shall prosecute the work contemplated under the contract with adequate equipment, labor and material and shall carry on the work a sufficient number of hours and shifts each day on a schedule which will insure completion of the contract within the time specified.

A preconstruction conference will be held prior to the start of construction. This conference will be between the contractor, the engineer and other parties interested in the proposed construction. The contractor shall determine a satisfactory date for this conference and advise the engineer several days in advance in order that parties concerned can be advised. The contractor should plan to attend, accompanied by such persons as he deems advisable. It is imperative that the person designated by the contractor, to be in direct charge of construction of the project be present.

Operations will not be permitted at any time, other than daylight, on any class of work without written consent of the engineer. Permission to perform night work may be rescinded by the engineer at any time when satisfactory results are not being obtained. Work at night will not be permitted under any circumstances, unless the contractor furnishes the flood lighting on the operations of sufficient intensity to insure the same degree of accuracy and quality of workmanship as would be obtained by daylight. Lights on equipment employed in performance of the work will not be accepted as satisfactory lighting.

The necessity of suspending and resuming work on the contract will be determined by the engineer.

The engineer will give consideration to unsuitable weather or to such other conditions as are considered unfavorable for the suitable prosecution or protection of the work.

The contractor shall not suspend work on any portion of the contract without a written order by the engineer. Suspension of the work ordered by the engineer shall not furnish grounds for claims by the contractor for damages or extra compensation for a period of work suspension. The necessity of discontinuing any portion of the work for reason of unfavorable conditions will be determined by the engineer. Upon failure or negligence on the part of the contractor to carry out the order of the engineer to perform work under the contract in accordance with the provisions thereof, the engineer may suspend the work for such period as he considers necessary and contract time will continue to be charged. Time lost by reason of such failure or negligence or in replacing improper work or materials shall not furnish grounds to the contractor for claiming an extension of time or extra compensation and shall not release the contractor from damages or liability for failure to complete work within the allotted contract time. The contractor shall take every precaution to prevent any damage or unreasonable deterioration during the work suspension.

Should it become necessary to suspend work for an indefinite period, the contractor shall store all materials in such manner that they will not ob-

struct or impede the traveling public nor become damaged in any way. He shall provide suitable drainage of the roadway by opening ditches, shoulder drains, and the like, and undertake other precautions the engineer may direct.

If the contractor shall suspend operations during the construction life of the contract, without a written order from the engineer, contract time will continue to be charged and the contractor shall be responsible for and shall at his own expenese furnish all work and materials required for satisfactory maintenance of the project and its restoration accrued during the delayed period.

The contractor shall reimburse the Department of Highways for all field project engineering charges accrued during the delaying period resulting from his actions in suspending operation, at any time prior to the expiration date of the specified contract time.

When it is impractical to begin work on the effective date of the "Notice to Proceed", such as the lateness of the season, inclement weather, roadway not yet ready, field engineering not far enough advanced to permit an orderly prosecution of the work, or other conditions not within the control of the contractor, the engineer shall so record in his weekly "Assessment of Contract Time" and no time shall be charged accordingly. When conditions are such that orderly prosecution of the work may proceed the engineer will so notify the contractor and begin charging contract time.

08.04 LIMITATION OF OPERATIONS. The contractor shall conduct the work at all times in a manner and a sequence that will assure the least interference with traffic. He shall have due regard to the location of detours and to the provisions for handling traffic. He shall not open up work to the prejudice or detriment of work already started. The engineer may require the contractor to finish a section on which work is in progress before work is started on any additional sections if the opening of such section is essential to public convenience. At no time during the prosecution of the work shall more than two miles of roadway be under construction or obstructed to traffic without permission of the engineer. The express intent of this provision fully provides for work sequences that will benefit the improvement as a whole.

Therefore, any contractor shall, when directed by the engineer, perform work as is necessary to expedite completion.

08.05 CHARACTER OF WORKMEN; METHODS AND EQUIPMENT. The contractor shall at all times employ sufficient labor and equipment for

prosecuting the several classes of work to full completion in the manner and time required by these specifications.

All workmen shall have sufficient skill and experience to perform properly the work assigned to them. Workmen engaged in special work or skilled work shall have sufficient experience in such work and in the operation of the equipment required to perform all work properly and satisfactorily.

A person employed by the contractor or by a subcontractor who does not perform his work in a proper and skillful manner or who is intemperate or disorderly shall, at the written request of the engineer, be removed forthwith by the contractor or subcontractor employing such person. He shall not be employed again on the work without the approval of the engineer.

Should the contractor fail to remove a person or persons as required above, or fail to furnish suitable and sufficient personnel for the proper prosecution of the work, the engineer may suspend the work by written notice until the orders are complied with.

All equipment which is used or proposed to be used on the work shall be of sufficient size and in such mechanical condition as to meet requirements of the work and to produce a satisfactory quality of work. Equipment used on the project shall be such that no injury to the roadway, adjacent property, or other highways will result from its use. Adequate lighting shall be in operation on all vehicles, power shovels and similar movable equipment when operated at night.

When the methods or equipment to be used by the contractor in accomplishing the construction are not prescribed in the contract, the contractor is free to use methods or equipment that he demonstrates to the satisfaction of the engineer that will accomplish the contract work in conformity with the requirements of the contract.

When the contract specifies that the construction be performed by the use of certain methods and equipment, such methods and equipment shall be used unless others are authorized by the engineer. If the contractor desires to use a method or type of equipment other than those specified in the contract, he may request authority from the engineer to do so. The request shall be in writing and shall include a full description of the methods and equipment to be used and an explanation of the reasons for desiring to make the change. If approval is given, it will be on the condition that the contractor shall be fully responsible for producing construction work in conformity with contract requirements.

If, after trial use of the substituted methods or equipment, the engineer determines that the work produced does not meet contract

requirements, the contractor shall discontinue the use of the substitute method or equipment and shall complete the remaining construction with the specified methods and equipment. The contractor shall remove the deficient work and replace it with work of specified quality, or take such other corrective action as the engineer may direct. No change will be made in basis of payment for the construction items involved nor in contract time as a result of authorizing a change in methods or equipment under these provisions.

08.06—DETERMINATION AND EXTENSION OF CONTRACT TIME

Time allowed for performance of the work, furnishing materials and completion of the contract will be determined by either the "Calendar Date" or the "Working Day" provision. The completion date or total time allowed will be stipulated in the proposal form and in the contract.

(A) Calendar Date Contracts. When the contract provides for a fixed calendar date for completion it shall be the date on which all work on the project shall be satisfactorily completed. Time extensions for extra work and overruns of contract date will be computed in the same manner as for working day contracts.

Delay in awarding the contract, of more than one day after the opening of bids will extend the completion date the number of working days from the day of opening of bids to the day of awarding the contract.

(B). Working Day Contracts. When the proposal form and contract provides that completion of work be accomplished on a working day basis, it shall consist of the number of working days stated in the contract counting from the effective date of the Notice to Proceed with work.

A working day is defined as any day except Saturdays, Sundays, holidays designated as non-working days, and days on which the contractor is specifically required by the Special provisions to suspend construction operations and all days during the period of November 16 through April 15. Holidays designated as non-working days are: New Years Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day, Veteran's Day and Christmas Day. If a designated holiday falls on a Sunday, the following Monday is a non-working day.

Each working day beginning with the effective date of the Notice To Proceed will be charged against the contract except any day when inclement weather, or the aftermath of inclement weather, prevents the contractor from performing the sequence of operations that should be in progress at that time for a minimum of 60 percent of the normal daily schedule being worked.

If the contractor is unable to begin work at his regular starting time because of inclement weather or the effects of inclement weather and his crew is dismissed as a result thereof, no time shall be charged for that day.

The contractor shall not perform construction operations on Sundays or holidays without authorization by the Division Construction Supervisor, except for pre-wetting, making emergency repairs to the project, providing protection for the public and the work. No time will be charged to perform these necessary functions. When work is done by the contractor on Saturdays, Sundays or holidays, those days shall be evaluated as though they are working days (except during the period November 16 through April 15 when no time is to be charged for any work). Producing and stockpiling surfacing aggregates are not a part of these restrictions and may be accomplished on Saturdays, Sundays, holidays and during a work suspension period with no charge against the contract time with the following exception:

The period between November 15th through April 15th is chargeable for State Maintenance Stockpiling Projects. Time will be charged for all working days beginning with the effective date of the Notice to Proceed with work. Inclement weather and its after effects will be treated the same as provided for above.

Determination of each working day as chargeable or non-chargeable will be made and agreed upon during such day by conference between the engineer and the contractor's representative. Every Monday, except for the period November 16 through April 15, the engineer will furnish the contractor a weekly report showing the number of working days charged to the contract for the preceding week, the number of working days previously charged to the contract, the number of working days specified for completion of the contract, the number of working days of time extensions approved, except the extensions covered under 08.06(C) second paragraph, and the number of working days remaining to complete the contract. The contractor will be allowed 10 days after receiving the report in which to file a written protest with the engineer of any alleged discrepancies in the time assessed on the weekly report; otherwise the time assessed will be deemed to have been accepted by the contractor as correct.

(C) Extensions.

If the contractor finds it impossible, for reasons beyond his control, to complete the work on either calendar date or working day contracts within the contract time as specified, or as extended in accordance with the provisions of this Article, he may at any time prior to the expiration of the

contract time as extended, make a written request to the engineer for an extension of time setting forth therein the reasons justifying his request. The contractor's plea that insufficient time was specified is not a valid reason for extension of time. If the Department of Highways finds that the work was delayed because of conditions beyond the control of and not the fault of the contractor, they will extend the time for completion in such amount as the conditions justify. The extended time for completion will then be in full force and effect the same as though it were the original time for completion.

The number of days for performance allowed in the contract as awarded is based on the original quantities as defined in Article 02.04. No decrease in contract time will be made for any decrease in a contract item. If fulfillment of the contract requires performance of work in greater quantities than those set forth in the contract, the contract time allowed for performance will be increased on a basis commensurate with the quantity and difficulty of the added work. The minimum time allowed for any additional work will be computed by the following formula:

$$\text{Time Extension in days} = \frac{\text{Total dollar amount of additional work}}{\text{Total amount of contract as awarded}} \times \text{The contract time as awarded}$$

The time extension as computed by the above method will be rounded to the nearest whole day.

No additional time will be allowed for increases in percentages of asphalt or for adding Anti-Stripping additives to asphaltic materials.

If requested by the contractor, non-chargeable time will be considered when the late delivery of materials, beyond the control of the contractor, prevents him from proceeding with at least 60 percent of the normal daily schedule of operations that should be in progress at that time. The contractor shall submit to the Project Unit Manager written documentation substantiating the reasons for the late delivery or non-availability of materials. Such documentation shall be from the original supplier and shall show dates the material was ordered by the contractor and the reason for late delivery or non-availability of the material. The contractor shall also include his statement wherein he elaborates about his efforts to obtain materials from alternate suppliers.

08.07—FAILURE TO COMPLETE ON TIME

A daily charge will be made against the contractor for each working day that any work shall remain uncompleted after elapse of contract time, or after a calendar date as specified. This daily charge, determined from the

table below, will be deducted from any money due the contractor. This deduction will not be considered a penalty but as liquidated damages. Due account shall be taken of adjustment of the contract time for completion of work granted under provision of Article 08.06.

The schedule for liquidated damages will be:

ORIGINAL CONTRACT AMOUNT		DAILY CHARGE
From More than	To and Including	Working Day or Fixed Date
\$ 0	\$ 10,000	\$ 28.00
\$ 10,000	\$ 25,000	\$ 42.00
\$ 25,000	\$ 50,000	\$ 70.00
\$ 50,000	\$ 100,000	\$105.00
\$ 100,000	\$ 500,000	\$140.00
\$ 500,000	\$1,000,000	\$210.00
\$1,000,000	\$2,000,000	\$280.00
\$2,000,000	-----	\$420.00

Permitting the contractor to continue and finish the work or part of it after the time fixed for its completion, or after the date to which the time for completion may have been extended, will in no way operate as a waiver on the part of the Commission of its rights under the contract.

The Commission may waive such portions of the liquidated damages as may accrue after the work is in condition for safe and convenient use by the traveling public.

08.08 DEFAULT AND TERMINATION OF CONTRACT. The contractor will be held in default, or have his contract terminated, at the discretion of the Commission, if he:

- (A) Fails to begin the work under the contract within the time specified in the "Notice to Proceed," or
- (B) Fails to perform the work with sufficient workmen and equipment or with sufficient materials to assure the prompt completion of said work, or
- (C) Performs the work unsuitably or neglects or refuses to remove materials or to perform anew such work as may be rejected as unacceptable and unsuitable, or
- (D) Discontinues the prosecution of the work, or
- (E) Fails to resume work which has been discontinued within a reasonable time after notice to do so, or
- (F) Becomes insolvent or is declared bankrupt, or commits an act of bankruptcy or insolvency, or

(G) Allows a final judgment to stand against him unsatisfied for a period of 10 days, or

(H) Makes an assignment for the benefit of creditors, or

(I) For any other cause whatsoever, fails to carry on the work in an acceptable manner.

The engineer will give notice in writing to the contractor and his surety of such delay, neglect, or default.

If the contractor or surety, within a period of ten days after such notice, does not proceed in accordance therewith, then the Department will, upon written notification from the engineer of the fact of such delay, neglect or default and the contractor's failure to comply with such notice, have full power and authority without violating the contract, to take the prosecution of the work out of the hands of the contractor. The Department may appropriate or use any or all materials and equipment on the ground as may be suitable and acceptable and may enter into an agreement for the completion of said contract according to the terms and provisions thereof. Other methods may be used which in the opinion of the engineer will be required for the completion of said contract in an acceptable manner.

All costs and charges incurred by the Department together with the cost of completing the work under contract, will be deducted from any monies due or which may become due the contractor. If such expense exceeds the sum which would have been payable under the contract, then the contractor and the surety shall be liable and shall pay to the Department the amount of such excess.

(J) The Commission may terminate the contract or portion thereof by written notice, when in the event of a national emergency or for other reasons beyond the control of the Department of Highways, such termination becomes necessary for the best interest of the Department.

Upon such termination, the contractor will be entitled to the full amount of the estimate, including any retained percentage, for the work actually done by him under the terms and conditions of the contract up to the date of the service of notice of termination. However, no claim for loss of anticipated profits will be considered.

In addition, the contractor will be reimbursed by the Department for expenditures which, in the judgment of the engineer, are not otherwise compensated for. Organization of the work, and other overhead expenses, (when not otherwise included in the contract) and moving equipment and materials to and from the project will be considered, the intent being that an equitable settlement will be made with the contractor.

Acceptable materials, obtained or ordered by the contractor for the work and that are not incorporated in the work will, at the option of the contractor, be purchased from the contractor at actual cost as shown by receipted bills and actual cost records at such points of delivery as may be designated by the engineer.

Termination of a contract or a portion thereof shall not relieve the contractor of his responsibilities for the completed work, nor shall it relieve his surety of its obligation for and concerning any just claim arising out of the work performed.

Notice will be considered to have been served upon the contractor when delivery to the person in charge of any office used by the contractor, the contractor's superintendent, or other authorized representative in charge of the job has been completed or such notice has been sent by registered mail to the contractor at his last known place of business.

The contract will be considered to have been completely fulfilled when all work has been completed and accepted by the Department and the final estimate has been accepted by the contractor and paid. The contractor will then be released from further obligation under the contract except as set forth in his contract bond.

NOTES

[illegible]

SECTION 9

MEASUREMENT AND PAYMENT

09.01 MEASUREMENT OF QUANTITIES. All work completed under the contract will be measured by the engineer according to United States standard measure.

A station when used as a definition or term of measurement will be 100 linear feet.

The method of measurement and computations to be used in determination of quantities of material furnished and of work performed under the contract will be those methods generally recognized as conforming to good engineering practice.

Unless otherwise specified, longitudinal measurements for area computations will be made horizontally, and no deductions will be made for individual fixtures having an area of nine square feet or less. Unless otherwise specified, transverse measurements for area computations will be the neat dimensions shown on the plans or ordered in writing by the engineer.

Structures will be measured according to neat lines shown on the plans or as altered to fit field conditions.

All items which are measured by the linear foot, such as pipe culverts, guardrail, underdrains, and the like, will be measured parallel to the base or foundation upon which such structures are placed, unless otherwise shown on the plans.

In computing volumes of excavation the average end area method or other acceptable methods will be used.

The term "gage," when used in connection with the measurement of plates, will mean the U.S. Standard Gage except that when reference is made to the measurements of galvanized sheets used in the manufacture of corrugated metal pipe, metal plate pipe culverts and arches, and metal cribbing, then the material will be specified and measured as sheet thickness in inches.

When the term "gage" refers to the measurement of wire, it will mean the wire gage specified in AASHTO M 32.

The term "ton" will mean the short ton consisting of 2,000 pounds avoirdupois. All materials which are measured or proportioned by weight shall be weighed on accurate, approved scales by competent, qualified personnel at locations designated by the engineer. If material is shipped by rail, the car weight may be accepted provided that only the actual weight of material be paid for. Car weights will not be acceptable for material to be passed through mixing plants. Vehicles used to haul

material being paid for by weight shall be weighed empty daily at such times as the engineer directs, and each vehicle shall bear a plainly legible identification mark.

Materials to be measured by volume in the hauling vehicle shall be hauled in approved vehicles and measured therein at the point of delivery. Vehicles for this purpose may be of any size or type acceptable to the engineer, provided that the body is of such shape that the actual contents may be readily and accurately determined. All vehicles shall be loaded to at least their water level capacity and all loads may be leveled when the vehicles arrive at the point of delivery.

When requested by the contractor and approved by the engineer in writing, material specified to be measured by the cubic yard may be weighed and such weights will be converted to cubic yards for payment purposes. Factors for conversion from weight measurement to volume measurement will be determined by the engineer and shall be agreed to by the contractor before such method of measurement of pay quantities is used.

Bituminous materials will be measured by the gallon or ton. Volumes will be measured at 60 degrees F. or will be corrected to the volume at 60 degrees F. using ASTM D 1250.

Net certified scale weights based on certified volumes in the case of rail shipments will be used as a basis of measurement, subject to correction when bituminous material has been lost from the car or the distributor, wasted, or otherwise not incorporated in the work.

When bituminous materials are shipped by truck or transport, net certified weights or volume subject to correction for loss or foaming, may be used for computing quantities.

Cement will be measured by the short-ton or hundred-weight. A short-ton shall be considered to be 2,000 pounds and a hundred-weight to be 100 pounds.

Timber will be measured by the thousand feet board measure (M.B.M.) actually incorporated in the structure. Measurement will be based on nominal widths and thicknesses and the extreme length of each piece.

The term "lump sum" payment when used as an item of payment will mean complete payment for the work described in the contract.

When a complete structure or structural unit (in effect, "lump sum" work) is specified as the unit of measurement, the unit will be construed to include all necessary fittings and accessories.

Rental of equipment will be measured by time in hours of actual working time and necessary traveling time of the equipment within the limits of the project unless special equipment has been ordered by the

engineer in connection with force account work, in which case travel time and transportation to the project will be measured.

When standard manufactured items are specified such as fence, wire, plates, rolled shapes, pipe conduit, etc., and these items are identified by gage, unit weight, section dimensions, etc., such identification will be considered to be nominal weights or dimensions. Unless more stringently controlled by tolerances in cited specifications, manufacturing tolerances established by the industries involved will be accepted. Other quantities will be computed in units indicated in the proposal form according to well established engineering principles and no local rules or customs at variance therewith will be considered.

09.02 SCOPE OF PAYMENT. The contractor shall receive and accept compensation provided for in the contract as full payment for furnishing all materials and for performing all work under the contract in a complete and acceptable manner and for all risk, loss, damage, or expense of whatever character arising out of the nature of the work or the prosecution thereof, subject to the provisions of article 07.19.

If the "Basis of Payment" clause in the specifications relating to any unit price in the bid schedule requires that the said unit price cover and be considered compensation for certain work or material essential to the item, unless otherwise specified, this same work or material will not also be measured or paid for under any other pay item.

The payment of any current or final estimate, or of any retained percentage, shall in no way or in no degree prejudice or affect the obligation of the contractor to submit for final acceptance a completed improvement in accordance with the requirements of the plans, specifications, special provisions, and supplemental agreements.

In meeting the requirements of the provisions of Chapter 195, Laws of Montana, 1967, the Department will withhold one per cent of any payments on contracts including force account work, exceeding \$1,000.00 dollars paid a contractor on a construction contract awarded by the Department. Any payments by a prime contractor to a subcontractor are also subject to this one-percent gross receipts fee. The prime contractor will be required to withhold one per cent of any payments made by him to a subcontractor.

09.025 FREIGHT RATES

(A) General. The bid prices for items of work involving materials, as listed in Part (B) which are furnished by the contractor and which become

a part of the finished project are assumed to be based on common carrier rates in effect on the date of opening bids.

If, between the date of bid opening and the date on which the designated materials are shipped to the project, the freight rates are increased, causing an additional cost to the contractor, the Department will reimburse the contractor in the exact amount of cost caused by such increase provided the claim is supported by proper certification originating with the common carrier.

If, between the date of bid opening and the date on which such designated materials are shipped to the project, the freight rates are decreased resulting in a saving to the contractor, the Department will deduct the exact amount of cost caused by such decrease from any monies due or which may become due the contractor.

The Department will not reimburse the contractor for an increase in freight rates when the materials are shipped after the time allowance for the completion of the contract has expired, nor shall the contractor owe the Department any money under that condition because of a decrease in rates.

Any decrease or increase, due to freight rate changes, totaling less than one hundred dollars on the project as awarded to the contractor, or modified by agreement, will not be eligible for reimbursement by the contractor nor payment by the Department.

The Department will not be responsible for any damage which the contractor might suffer on account of delays or irregularities on the part of the railroad or other conveyor and the contractor shall bear the cost of all demurrage and care rentals.

Any payment due the contractor, or any payment due the Department, will be made in the execution and consummation of the project's final estimate, or before that if necessary to assure adequate funds.

Compensation will be limited to increase or decrease in freight rates only for materials transported by rail or common carrier trucks or specialized truck carriers, the exact rates for which are fixed by the Department of Public Service regulation or the United States Interstate Commerce Commission.

Compensation for increased freight rates will be limited (1) to materials shipped direct to or in care of the contractor and on which he pays the freight separately and apart from the purchase of the materials and (2) to the materials which he purchases F.O.B. delivery site for the project, with a clause in the purchase agreement whereby the purchase price for the material will be adjusted on account of a change in freight rates.

No compensation will be allowed for increased freight rates where the

contractor cannot or does not present to the Department original receipted freight bills, or a certified, receipted statement showing information usually on a bill of lading and of a form approved by the Department. When there is an increase, or decrease in freight rates, the contractor will be required to submit the necessary rate information.

(B) Materials Subject To Common Carrier Rate Adjustment. This article of the specifications shall be applicable only to the common carrier rates on the material for the items of work as shown hereinafter.

1. Cement and aggregates for Portland Cement concrete pavement.
2. Cement and aggregates for major concrete structures, concrete surface drains, concrete curb and gutter, concrete sidewalks and driveways, concrete monuments and guard post and other similar structures.
3. Cement for cement stabilized base courses.
4. Bituminous material for bituminous treated base course, prime or tack coat, bituminous road or surface course, hot mix asphaltic concrete pavement, seal coat and similar applications.
5. Mineral filler and hydrated lime for bituminous mixtures.
6. Structural and Reinforcing Steel. This clause shall govern only when the contract requires such steel in weight of 250,000 pounds or more. This weight may be any combination of structural and reinforcing steel.

(C) Before the final estimate and at any time prior thereto upon request of the State the contractor must furnish the following information and documents to the State for the purpose of making any adjustments in payment to the contractor on account of any change in the cost of materials listed in Paragraph (B) resulting from increases or decreases in the amount or cost of freight rates or other handling charges, to wit:

1. Certified copies of purchase agreements, receipted freight bills, or conditions thereof covering the purchase of the materials listed herein on which the freight is to be set forth separately and apart from the specific price of the materials regardless if they are purchased F.O.B. delivery site on the project or with the freight as a separate pay item.
2. In the absence of a formal material purchasing agreement, the contractor shall furnish an affidavit to this effect and setting forth the conditions under which the materials were purchased and delivered to the project.
3. Produce additional evidence as may be required, by the State, to show that and to what extent the cost of the materials listed herein have been revised by reason of an adjustment in freight rates or other factors affecting the specific amount or cost of freight rates, or any adjustments in the cost of handling the materials.

09.03 COMPENSATION FOR ALTERED QUANTITIES. When the accepted quantities of work vary from the quantities in the bid schedule, the contractor shall accept as payment in full, so far as contract items are concerned, payment at the original contract unit prices for the accepted quantities of work done. No allowance except as provided in article 04.02 will be made for any increased expense, loss of expected reimbursement, or loss of anticipated profits suffered or claimed by the contractor resulting either directly from such alterations or indirectly from unbalanced allocation among the contract items of overhead expense on the part of the bidder and subsequent loss of expected reimbursements therefor or from any other cause.

Quantities of concrete, roadway excavation, borrow excavation or structure excavation may include contingency quantities above computed quantities for bidding purposes. However, only those quantities of materials actually incorporated into the final construction will be eligible for payment. The allowances for increase or decrease in quantities provided in Article 04.02 are not applicable to aggregate surfacing bid and paid for in tons and on which the tons have been arrived at from an estimated weight per cubic yard. The contractor will be paid on the basis of the actual amount of aggregate placed to conform to plan dimensions, regardless of increase or decrease.

09.04 PAYMENT FOR EXTRA WORK. Payment for extra work will be made as provided for in these specifications.

(A) Unit Price or Lump Sum Basis. Extra work, performed in accordance with the applicable provisions of Articles 04.02 and 04.03, will be paid for at the unit prices or lump sum price agreed upon and specified in the order authorizing the work. Extra work may be paid by unit prices agreed upon by each party. Such extra work will be authorized by change order.

(B) Force Account Basis. Approved extra work paid for on a force account basis will be accounted for daily on report sheets signed by the authorized representative of each party. The daily report sheets are considered the true record of extra work. Where extra work on a "Force Account Basis" has been ordered by the engineer, in writing, as provided under Section 4, "Scope of Work," it will be paid for in the following manner:

(1) For all labor and foremen in direct charge of the specific operations, the contractor shall receive the rate of wage (or scale) agreed

upon in writing before beginning work for each and every hour that said labor and foremen are actually engaged in such work, plus 20 percent.

(2) The contractor will receive the actual delivered cost of all materials used, as shown on invoices, plus 15 percent. The quantity of material used shall be satisfactorily documented.

(3) For any machine-power tools or equipment including fuel and lubricants, which may be deemed necessary or desirable to use, the engineer will allow the contractor a reasonable rental price to be agreed upon in writing. Rental rates shall conform to the current issue of "Equipment Rental Rates", published by the Montana Department of Highways. When the booklet does not establish a rental rate for a particular piece of equipment, a price will be established by mutual agreement between the engineer and the contractor prior to the commencement of any work. The "agreed to" rental rate shall apply to the actual time the tools and equipment are in use on such work. To this rate no percentage shall be added.

(4) The contractor shall receive the actual cost, chargeable to force account work, of premiums for workmen's compensation insurance, performance bond, public liability and property damage insurance and social security, unemployment compensation, industrial accident, health and welfare expenses and such other expense as might be imposed by Federal or State laws, or both. The actual cost of the above expenses, with the exception of performance bond, will be increased by 20 percent. No surcharge will be allowed for the performance bond. The contractor shall furnish satisfactory evidence of the rate or rates paid for insurance, bond and other eligible expenses, including health and welfare.

(5) The compensation as herein provided shall be received by the contractor as payment in full for extra work done on a "force account" basis and shall include profit, superintendence, use of tools and equipment for which no rental is allowed, and profit.

(6) All statements for the extra work done on a "force account" basis shall be submitted on estimate forms furnished by the Department, accompanied by the original extra work order and the original or permanent-type copies of material and freight bills.

The contractor's record of extra work done on a "force account" basis will be checked by the inspector at the end of each day and a copy of these records, signed by both the inspector and the contractor's representative, forwarded to the engineer. Such claims shall be submitted to the engineer not later than the 10th day of the month following that in which the work was actually performed.

When extra work on a force account basis is performed by a subcontractor on the project in accordance with the provisions of an extra work order, a percentage based on the following table will be allowed in addition to the percentages in paragraphs (1), (2) and (4) above, to reimburse the prime contractor for the administrative expenses incurred in connection with the work. Bid items in the original contract are not to be considered as eligible for this administrative allowance.

\$	0 to	1,000.....	10%	
\$	1,000.01 to	\$10,000.....	\$100	plus 5% of excess over \$ 1,000
	Over \$10,000.01.....	\$550		plus 3% of excess over \$10,000

Approval of this additional percentage will be made after receipted invoices are furnished by the contractor.

No administrative expenses will be paid on a force account basis above the amount allowed the prime and subcontractor if work is done by a sub subcontractor.

Payment for extra work will be made as provided for in these specifications.

(C) Payment For Claims. Payment of costs involved in claims described in Article 05.16, for which Department liability has been established, will be based on the actual costs for materials, labor, equipment hours and incidentals used in the work under the claims. Such costs will be considered as extra and additional to the amount paid under one or a combination of the following: (1) Contract Bid Item Work, (2) Change Order, (3) Extra Work Order, (4) Supplemental Agreement.

The actual cost involved in payment of a claim shall not be considered as involving any of the percentages or methods used under Article 09.04 (A) or (B).

Actual costs will be determined from the contractors' project records of costs incurred by the work and as audited by a Department of Highways' auditor or an independent C.P.A.

09.05 ELIMINATED ITEMS. Should any items contained in the proposal be found unnecessary for the proper completion of the work, the engineer may upon written order to the contractor, eliminate such items from the contract, and such action shall in no way invalidate the contract. When a contractor is notified of the elimination of items, he will be reimbursed for actual work done and all costs incurred, including mobilization of materials prior to said notification.

09.06 PARTIAL PAYMENTS. In no case of this sort will any allowance be made for anticipated profits.

The Department of Highways will not withhold any retainage on the first 80 percent of the contract awarded amount, providing the Contractor does not become delinquent in any contractual or other obligations related thereto, and progress is satisfactory.

After 80 percent of the contract has been completed, 10 percent of each monthly progress estimate will be retained until 5 percent of the final 20 percent of the value of the contract awarded amount is attained.

However, if it is determined the Contractor has become delinquent in any contractual obligations, the retained amount will be computed at 10 percent of each monthly estimate.

In case the contract extends beyond the contract completion time, the sum specified in Article 08.07 of the Standard Specifications and Supplements thereto will be deducted from any money due the Contractor, not as a penalty, but as liquidated damages.

09.07 PAYMENT FOR MATERIAL ON HAND. Allowance may be made, at the discretion of the engineer, on progress estimates for the net cost of any materials, which are not subject to deterioration, and which are intended to become a permanent part of the project, provided the materials meet the requirements of the plans and specifications. Advance payment will not be made unless requested by the contractor. However, no advance payment will be allowed for any materials stored out of State. All materials which are approved and accepted by the engineer for payment shall be delivered and stored on the project, or in another place approved by the engineer. Advance payment for materials in storage will be made only as a reimbursement for monies actually expended, either directly or indirectly. Advance payment, when allowed for materials stored, shall in no case exceed the price bid for the incorporated articles. The contractor shall deliver to the engineer, certified copies of paid invoices, paid freight bills, or other information as the engineer may require. The materials shall be stored in a manner satisfactory to the engineer, but neither the approval and acceptance of the materials to be stored nor approval of the method of storage by the engineer shall relieve the contractor of the responsibility for the final quality of the materials as they are placed in the work.

Aggregates, stored on the project, for use in plant mix surfacing, will be accepted for advance payment only if they have been produced in conformity with applicable grading and material requirements.

09.08 ACCEPTANCE AND FINAL PAYMENT. When the project has been accepted as provided in article 05.15, the engineer will prepare the final estimate of the quantities of the various classes of work performed.

After approval of such final estimate by the contractor, he will be paid the entire sum found to be due after deducting all previous payments and all amounts to be retained or deducted under the provisions of the contract.

All prior partial estimates and payments will be subject to correction in the final estimate and payment.

The Department reserves the right to withhold all or part of final payments of money earned under the contract until all taxes and assessments due and owing to the State of Montana have been paid in full or in lieu thereof, a written release is directed to the Department from the State agency having a claim against the contractor.

The statutory time, 90 days, for filing claims against the contract bond shall date from the day of final acceptance of the project by affirmative action of the Department — see Sections 6-401 to 6-404, inclusive, Revised Codes of Montana, 1947, as amended.

The Department reserves the right to withhold from the contractor's final estimate an amount of money equal to all claims submitted to the Department against the contract or the contract bond. Only those claims submitted within 30 days after the Department's formal acceptance of the completed contract will be accepted by the Department. However, this specification provision is in no manner intended to restrict or bar the filing of a claim against the contract bond or contract sureties as provided for in Section 6-401 through 6-404, Revised Codes of Montana, 1947.

The Department reserves the right to withhold the amount of all timely claims from the final estimate owing to the contractor for a period of 90 days after the expiration of the 30 days allowed for filing claims after the Department's final acceptance of the contract. In the event that no legal proceedings have been pursued before the expiration of the 90 day period, the funds withheld shall be released to the contractor.

The engineer will immediately notify the contractor and his surety of all claims filed against the contract or bond.

If at the end of the stipulated 30 day period, no just claims have been filed with the Department against the contract or bond, the engineer may request formal permission from the contractor's surety to pay the final estimate.

The payment of the final estimate by the Department at the expiration of the stipulated 30 day period does not in any way relieve the contract bond of its responsibility for any unsatisfied claim or claims filed with the Department during the remaining portion of the statutory period.

After notifying the contractor and his surety of Department acceptance, the engineer will prepare the final estimate, including therein the amount and value of each class of work performed and including any

“extra work” and “extra materials.” Upon settlement of any claim or claims filed and expiration of the 30 days estimate retaining period, the engineer may transmit to the contractor a claim embodying the final estimate.

After approval of such final estimate by the contractor, he will be paid the entire sum found to be due, after deducting all amounts to be retained or deducted under the provisions of the contract. Erroneous or over-payments made by previous and partial payments shall be subject to correction in the final estimate.

09.09 PAYMENT FOR EXCESS CRUSHED COVER AGGREGATE When the contract provides that crushed cover aggregate shall be placed on the roadway it may not be practicable for the contractor to produce the exact amount required.

Sale of any excess crushed cover aggregate shall be at the contractor's option. However, if the contractor elects to sell excess material to someone other than the Department, from Department owned or optioned sources, he shall refund the royalty for the amount of excess material he so removes.

The Department will purchase unused crushed cover aggregate up to a maximum amount equivalent to the difference in the tonnage specified by the contract and the tonnage actually used on the roadway.

If the contractor does not elect to dispose of the material at the herein-scheduled prices, the material shall remain the property of the contractor but he shall have it removed prior to acceptance of the project.

When the contract provides for “Crushed Cover Aggregate” in accordance with Section 25, the Department will purchase any acceptable excess material in accordance with the following schedule per ton:

Grade	1	2	3	4
Cover Material.....	\$1.50	\$2.25	\$2.50	\$3.00
Stone Chips.....	\$2.75	\$3.00	\$3.50	— — —

If the contract unit price for cover material or stone chips in place is less than the amount listed for the respective item in the above schedule, the Department will compensate the contractor at the contract unit price.

09.10 PAYMENT FOR HAUL FOR EXCESS CRUSHED MATERIAL. Payment for haul from the crusher site, over the most practicable haul route, as determined by the Engineer, to the stockpile site will be allowed at the rate of \$0.15 cents per ton for haul distance in excess of 2,000 feet. (e.g.-for a haul distance of 3,200 feet, haul will be paid for

1,200 feet). No haul payment will be allowed when the distance is less than 2,000 feet. An exception to the foregoing is to be made for State Maintenance Stockpile Crushing Projects. On SMP projects, haul will be paid at the Contract Unit Price.

ARTICLE 09.20 - MOBILIZATION

(A) **General.** This item shall consist of preparatory work and operations performed by the contractor, including, but not limited to those necessary for the movement of his personnel, equipment, supplies and incidentals to the project site; for the establishment of all offices, buildings and other facilities necessary for all work on the project, for premium on bonds and insurance for the contract, and for other work and operations which must be performed or costs incurred before beginning work on the various items on the project site. Mobilizations costs for sub-contracted work shall be considered to be included.

(B) The original contract amount is the total price of the contract as bid and includes the Mobilization item. Partial payments will be made once each month as the work progresses based on the lump sum contract price for "Mobilization" as follows:

(1) When 5% of the original contract amount is earned from **other** bid items, 25% of the amount bid for mobilization, or 2½% of the original contract amount, whichever is lesser, may be paid.

(2) When 10% of the original contract amount is earned from **other** bid items, 50% of the amount bid for mobilization or 5% of the original contract amount, whichever is lesser, may be paid.

(3) When 25% of the original contract amount is earned from **other** bid items, 60% of the amount bid for mobilization, or 6% of the original contract amount, whichever is lesser, may be paid.

(4) When 65% of the original contract amount is earned from **other** bid items, 90% of the amount bid for mobilization, or 9% of the original contract amount, whichever is lesser may be paid.

(5) When 80% of the original contract amount is earned from **other** bid items, 100% of the amount bid for mobilization, or 10% of the original contract amount, whichever is lesser, may be paid.

(C) Upon completion of all work on the project, payment of any amount bid for mobilization in excess of 10% of the original contract amount will be paid.

Nothing herein shall be construed to limit or preclude partial payments otherwise provided for by the contract. Payment will be full compensation for all work necessary to complete the item.

(D) **Payment.** Payment will be made under:

PAY ITEM	PAY UNIT
Mobilization.....	Lump Sum

(E) **State Maintenance Stockpiles.** An exception to the above is the method of payment for the Mobilization item for State Maintenance stockpile contracts. For SMP contracts, Mobilization will be the percentage each stockpile site quantity bears in relation to the entire contract quantity. This percentage will be determined by the Department of Highways. The amount established as payment for Mobilization for each site will be paid in its entirety with the first estimate for each site.

NOTES

SECTION 10

CLEARANCE OF RIGHT-OF-WAY

SUBSECTION 10.00 CLEARING AND GRUBBING

10.01 DESCRIPTION. This work shall consist of clearing, grubbing, removing, burning, burying, chipping and otherwise disposing of vegetation and debris within the limits of the right-of-way and easement areas, except such objects as are designated to remain or are to be removed in accordance with other sections of these specifications. This work shall also include the preservation from injury of vegetation and objects designated to remain.

The work shall be classified as follows:

(A) **"Clearing"** shall consist of the felling of trees, and disposal of stumps, brush, windfalls, logs, limbs, sticks, piles of sawdust, rubbish, debris, vegetation and other objectionable matter occurring within the clearing limits as hereinafter defined or which interfere with excavation, embankment or the designated clear vision areas.

(B) **"Grubbing"** shall consist of the removal from the ground and the disposal of roots, stumps, stubs, together with duff, matter roots and debris from the grubbing limits, as hereinafter defined.

(C) **"Clearing and Grubbing"** shall consist of performing both "clearing" and "grubbing" as set forth above.

(D) **"Methods of Disposal"** shall consist of removing as directed and burning or burying or chipping or otherwise disposing of the accumulations from clearing, grubbing or clearing and grubbing operations.

10.02 CONSTRUCTION METHODS.

(A) **General.** Clearing, grubbing or clearing and grubbing shall be done at such times and in such manner that the surrounding vegetation, adjacent property and anything designated to remain on the right-of-way shall not be damaged. The dragging, piling and disposing of debris, and work which may be injurious to vegetation, shall be confined to areas which carry no vegetation or which will be covered by embankments or disturbed by excavations.

Vegetation adjacent to streams, ponds or lakes shall be preserved and

kept safe from injury unless this vegetation is in direct conflict with construction operations and designated to be removed by the engineer. If any vegetation designated to be preserved becomes damaged or destroyed by the contractor, it shall be replaced to the satisfaction of the engineer at no cost to the State.

The engineer will designate trees, shrubs, plants or other objects which will remain. The contractor shall preserve all objects so designated.

The contractor shall avoid injury to trees, shrubbery, vines, plants, grasses, and other vegetation growing on areas outside of the slope limits of excavation and embankment. The contractor shall paint as required cut or scarred surfaces of trees or shrubs selected for retention. The paint shall be an approved asphaltum base paint prepared especially for tree surgery.

The contractor's pioneer roads or work trails shall be located no less than 20 feet inside of the actual clearing limits. This 20 feet will preclude the under-cutting of live root systems supporting vegetation adjacent to but outside of the designated clearing limits.

As designated by the engineer, anticipated potential hazards such as "widow makers", leaning trees (alive or dead), snags and the like within the right-of-way, shall be close cut and removed.

Clearing, grubbing or clearing and grubbing shall be kept a reasonable distance, approximately 1,000 feet or more ahead of grading operations. The engineer may direct, in areas where erosion or siltation is anticipated, that grubbing be confined to the area over which excavation is to be actively prosecuted within approximately 30 days following grubbing operations. Depressions resulting from grubbing operations but outside the roadbed, if not free draining shall be made so by backfilling with suitable material or grading to drain. Where scour is likely to occur, temporary erosion control settling basins shall be constructed prior to any scour occurring.

Staked construction limits include such areas as cuts, fills, channel changes, ditches, fence lines, utility relocation, roadside development, clearing, selective thinning for adequate sight distance grubbing and similar designated areas.

Not less than 15 days prior to disposing of material, the contractor shall submit to the engineer a proposal describing the disposal sites. The proposal will be reviewed for approval based on its effects on completed construction and the environmental effect on adjacent areas. The proposal shall be amended as required by the engineer. Materials, from clearing and grubbing operations, shall not be disposed of until the proposal is approved.

(B) Clearing. Clearing shall be within and to the staked construction limits, with a tolerance not to exceed five feet outside these limits. Clearing for right-of-way fencing shall be the obligation of the fencing contractor.

Trees, stumps, brush, shrubs and other vegetation shall be cut off within six inches of the ground and where feasible, trees shall be felled toward the center of the area to be cleared so they will not endanger traffic or injure other trees or objects designated to remain.

The contractor shall remove dead vegetation, logs, stumps, limbs, sticks, piles of sawdust, rubbish or debris and other undesirable matter occurring on areas where live shrubbery, brush or trees occur. Designated vegetation is to be left in place.

Timber having commercial value (logs with a minimum inside bark diameter of six inches and a length of eight feet or more and other timber which can be marketed for poles, posts, pulpwood and the like) shall be cut into logs in accordance with established logging practice. Any loss from breakage, felling or handling, may be charged back against the contractor. Logs unless otherwise specified shall be stacked in convenient places along the roadway or at other locations that are convenient for loading. Logs shall remain the property of the Department of Highways. Timber within a National Forest shall not be cut or destroyed without obtaining permission from the National Forest Service office responsible for the area concerned. All timber having commercial value, cut from the National Forest land, shall remain the property of the United States, to be disposed of as the Forest Service officer may determine.

(C) Grubbing. Grubbing shall be within and to the staked construction limits with a tolerance not to exceed five feet outside these limits.

All stumps, roots, logs or other timber more than three inches in diameter and all brush, matted roots and other debris within the grubbing limits, shall be pulled or otherwise removed to a depth of not less than twelve inches below the original ground surface.

When authorized, the contractor may leave stumps and non-perishable solid objects provided they do not extend more than six inches above the ground line or low water level, or when they will be covered with a minimum of four feet of sub-grade or slope embankment.

(D) Clearing and Grubbing. Clearing and Grubbing shall be done in accordance with provisions of (B) and (C) above.

(E) Methods of Disposal. The contract will specify the methods of disposal of all brush, stumps, windfalls, slash, timber having no commercial value and any other debris resulting from clearing, grubbing or clearing and grubbing operations.

(1) BURNING.

General. The intention of the burning specification is to dispose of combustible materials without generating undesirable quantities of particulate matter or smoke.

Material four inches in diameter or smaller may be open burned in areas and under conditions approved by the Air Quality Bureau of the State Department of Health and Environmental Sciences.

For materials larger than four inches in diameter, two methods are included in these specifications, the "air curtain destructor" method and the "forced air distribution" method. However, the contractor is encouraged to consider new burning techniques as they become developed.

When burning is permitted by contract, the contractor shall have a permit from the Air Quality Bureau. The permit will stipulate the conditions under which open burning will be accomplished and will specify whether Method 1 or 2 of Article 10.02 (E) (1) be used, or approve some other method of disposal proposed by the contractor. Burning shall be accomplished under the constant care of competent watchmen.

Burning shall normally be performed prior to grading operations. Failure to secure burning permits shall not be cause for delay in removal of debris from within areas affected by other operations. If the contract is materially delayed because of failure to secure burning permits, the Department of Highways will not allow any additional compensation for, nor grant an extension in the contract time, to make allowance therefore.

Pits required in either method of burning may be located within the right-of-way limits provided locations selected are compatible with this specification and all pits, ashes and debris are disposed of in accordance with Article 10.02 (E) (2), Burying. Pits shall not be located in areas exposed to possible measureable amounts of free flowing water or in any areas under ditch sections. Pits and incinerators shall be located distant enough from standing vegetation so as not to cause any damage or fire hazard when burning. All pit locations are subject to the approval of the engineer.

Equipment shall be used that will prevent dirt and other non-combustible material from entering the pit.

Prior to placing any stumps or other difficult-to-burn materials in a pit, a very hot fire shall be maintained. Sufficient quantities of the more combustible materials shall be fed continuously to the fire when burning difficult-to-burn materials. Burning material shall not be allowed to produce undesirable quantities of smoke except for very short periods of time when starting or stopping a fire.

Method 1.

Burning by this method involves the use of an "air curtain destructor". The type of air curtain destructor proposed for use shall be subject to the approval of the Air Quality Bureau for the Montana State Department of Health & Environmental Sciences but only commercially produced destructors or destructors following a standard commercial design shall be considered. Approval for use of a certain type of destructor shall not be construed as acceptance of the burning results.

In the event the destructor does not control the smoke and particulate matter at a level acceptable to the Department of Health & Environmental Sciences, the engineer may shut down burning operations and require corrective action before permitting a start-up.

Method 2.

Burning by this method involves high heat burning in open pits or incinerators using a forced air distribution system entering the bottom of the pit or incinerator.

When this method of burning is allowed it shall be accomplished only when good smoke dispersing atmospheric conditions are forecast by the National Weather Service.

If dimensions are not specified for pits and incinerators by the manufacturer, the minimum dimensions shall be approximately 20 feet wide, 30 feet long and ten feet deep; however, on-the-job practice may indicate different dimensions to be more effective and changes may be made to the more effective dimensions at the discretion of the engineer. If water free pits cannot be constructed or maintained, above ground level incinerators shall be used.

A forced air distribution system shall consist of a fan or fans, distribution pipes and outlet works, all of which shall be in balance with pit dimensions and oxygen demand to produce a hot blazing fire.

(2) BURYING.

The intention of the burying specification is to dispose of refuse from clearing and grubbing areas in a manner that will prevent water pollution, unsightliness or other deleterious effects from such refuse.

When disposal of clearing and/or grubbing debris is by burying it shall be disposed of in approved areas within the right-of-way outside the roadway prism limits, or in approved areas outside the highway right-of-way where the disposal will not detract from the aesthetics of the completed highway and adjacent area environment. Areas exposed to possible measurable quantities of free flowing water will not be approved.

When the contractor proposes to use an approved disposal area outside

the highway right-of-way, he shall first obtain a written permit from the property owner on whose property the disposal is to be made and file with the engineer said permit or a certified copy thereof together with a written release from the property owner absolving the State from any and all responsibility in connection with the disposal of material on said property.

Trenches and pits shall first be excavated. After cutting the debris to lengths as directed by the Project Manager, the debris shall be placed in alternating layers with excavated earth material. The alternating layers shall consist of four feet of debris covered with two feet of compacted soil. Stumps, logs and other large pieces shall be distributed to form a compact mass and minimize air voids. Buried logs shall not be stacked. Each composite layer of earth and unusable materials shall be placed in a manner to fill all voids. Disposal of material in borrow areas shall comply with requirements for burying in pits. All pits and borrow areas used for burying shall be topsoiled and seeded to establish vegetative cover commensurate with the proposed land use designated.

(3) CHIPPING SLASH.

The intention of the chipping slash specification is to dispose of debris from the project clearing operations and provide a source for mulch if the contract so requires. Should the contractor elect to produce the mulch necessary for the project by chipping slash, only the amount required for the project will be eligible for payment. The contractor may dispose of the excess chips by other means.

Wood and bark chips shall not exceed three-eighths inch in thickness and six square inches in area.

Chips, as required for the project, shall be stored in conveniently located stockpiles for future spreading on areas designated in the plans, or as directed by the engineer.

The stockpiles shall be located out of the way of road construction where they will not interfere with road building equipment or where they can become contaminated by road building operations. They shall be located on well drained sites above the high waterline of adjacent drainages.

10.03 METHOD OF MEASUREMENT. Measurement for Chipping, Clearing, Grubbing, or Clearing and Grubbing will be made by one or more of the following alternate methods:

(A) Lump Sum Basis. When items are included in the contract on a lump sum basis, no measurement of area or quantity will be made.

(B) Area Basis. The work to be paid for will be the number of acres and

fractions thereof acceptably cleared, grubbed or cleared and grubbed as specified within the limits shown on the plans or staked by the engineer.

(C) Individual Unit Basis.

(1) The diameter of trees will be measured at a height of 24 inches above the ground. Trees less than six inches in diameter will be classed as brush.

(2) Stumps will be measured by taking the average diameter at the cut-off.

(3) When the bid schedule indicates measurement by individual unit basis, the units will be designated and measured in accordance with the following schedule of sizes:

<u>Size of Diameter at Height of 24 Inches</u>	<u>Pay Item Designation</u>
6 inches but less than 12 inches	9 - inch size each
12 inches but less than 24 inches	18 - inch size each
24 inches but less than 36 inches	30 - inch size each
36 inches and over	48 - inch size each

(D) Chipping of Slash. When the contract specifies chip mulch, the quantity of mulch required for the project will be measured by the cubic yard, in the hauling vehicle at point of delivery prior to final placing.

10.04 BASIS OF PAYMENT. The accepted quantities of Chipping, Clearing, Grubbing or Clearing and Grubbing, will be paid for as full compensation at the contract unit prices as follows:

(A) Lump Sum Basis. Payments will be prorated for the percentage amount of completed work for each item listed as a lump sum in the bid schedule.

(B) Area Basis. Payment will be at the contract unit price per acre for each pay item in the contract.

(C) Individual Unit Basis. Clearing, grubbing or clearing and grubbing of trees and stumps larger than six inches in diameter will be paid for at the contract unit price for each tree or stump of the several sizes shown herein. This price and payment shall be full compensation for the removal and disposal of each tree or stump, and for furnishing all labor, materials, equipment, tools and incidentals necessary to complete the respective work.

(D) Chipping of Slash. Payment will be at the contract unit price bid per cubic yard for mulch, wood chips or mulch, bark chips.

(E) Disposal of Clearing, Grubbing, or Clearing and Grubbing Debris. No separate payment will be made for disposing of the debris resulting from clearing, grubbing, or clearing and grubbing except when the contract specifies that slash shall be chipped to produce the amount of wood and bark chips required for the project. Payment at the unit price bid for the mulch shall be full compensation for all labor, tools and equipment necessary for the producing, hauling and placing of the mulch.

(F) Exclusion. When the contract does not contain an estimated quantity or a lump sum item for clearing, grubbing or clearing and grubbing, the work will not be paid for directly, but will be a subsidiary obligation of the contractor absorbed in payment for other contract items.

SUBSECTION 10.30 REMOVAL OF STRUCTURES AND OBSTRUCTIONS

10.31 GENERAL. This work shall consist of the removal and the satisfactory disposal of all buildings, fences, structures, old pavements, abandoned pipe lines, foundations, debris, rubbish, rubble, junk or other obstructions which are not designated to remain. These obstructions may or may not be shown in whole or in part on the plans, but it will be incumbent upon the contractor to remove all such obstructions. Exceptions are, the removal and disposal of materials under other items in the contract, the salvaging of designated materials and the back filling of trenches, holes, and pits.

10.32 CONSTRUCTION REQUIREMENTS. The contractor shall raze, remove and dispose of all buildings and foundations, structures, fences, debris, and other obstructions, any portions of which are on the right-of-way, except utilities and those for which other provisions have been made for removal. All designated salvageable material shall be removed, without unnecessary damage, in sections or pieces which may be readily transported, and shall be stored by the contractor at specified places within the project limits.

Salvaged material shall be considered the property of the Department

of Highways. Written permission to use any of these materials in the contractor's operations is required.

Unusable combustible material shall be destroyed. Non-combustible material shall be disposed of in accordance with the requirements of Article 10.02 (E) (2). Basements or cavities left by structure removal shall be filled to the level of the surrounding ground and, if within the prism of construction, shall be compacted in accordance with Section 13.

Structures in use by traffic shall not be removed until satisfactory arrangements have been made to accommodate traffic.

(A) Removal of Bridges And Major Drainage Structures.

(1) Description. Removal of existing bridges and major drainage structures shall consist of the removal and satisfactory disposal of all portions of existing structures, and the maintenance of all traffic. Exceptions are, the portions required or permitted to be left in place in conformity with the specifications, plans or special provisions.

(2) Removal of Superstructures. Steel or timber super-structures required to be salvaged shall be dismantled, handled and stored in such manner to avoid damage to any member thereof. All members, pins, nuts, plates and the like, which are damaged, cut or destroyed as a result of the contractor's operations shall be repaired or replaced by the contractor at his sole expense. Concrete and masonry superstructures shall be removed and disposed of as provided herein unless otherwise specified.

Unless otherwise directed by the engineer, all members shall be match-marked with paint before they are dismantled. All pins, nuts, plates, and the like, shall be similarly marked to indicate their proper location; all pins, pin holes, and machined surfaces shall be painted with a mixture of white lead and tallow, and all loose parts shall be wired to adjacent members or packed in boxes with contents clearly marked thereon or index numbered for future identification.

(3) Removal of Substructures. Unless otherwise specified or ordered by the engineer, all portions of the substructures of existing structures above the bed of the stream, finished ground surface, or ground surface as it existed before the work was started, and all portions below the bed of the stream or ground surface which interfere in any way with the new construction, shall be removed. Blasting or other operations which might endanger the new work shall be completed prior to the construction of any part of the new structure.

Where piles compose the substructure, or a part thereof, the contractor shall cut off the piles one foot below the finished ground surface, or pull

them, as he prefers. However, if they interfere with the new construction, he shall remove them completely.

The substructures for temporary bridges shall be removed as required herein for the substructures of existing structures.

(4) Disposal of Materials Removed.

(a) Structural Steel. Structural steel members removed from the old structures shall, unless otherwise specified or directed, be stored in a neat and presentable manner in designated locations within the right-of-way and adjacent to the site of the work. Members of structures which are to be re-erected and all steel beams shall be stored above the ground surface on skids or otherwise protected as directed.

(b) Concrete and Masonry. Concrete and masonry which is removed from old structures shall, as far as practicable, be placed in backfills or approach embankments, in conformance with the requirements of Section 11.03 (I), or shall be used to riprap the slopes of the embankments or the channel if specified on the plans. Concrete or masonry which cannot be placed in backfills or embankments or used as riprap shall be disposed of as directed and in such manner as to prevent damage to property or the creation of unsightly conditions.

(c) Timber and Other Materials. All timber and other materials having salvage value shall be piled up in a neat and presentable manner on skids above ground in designated locations, within the right-of-way and adjacent to the site of the work.

(d) Ownership of Materials Removed. All materials having salvage value shall be disposed of as provided herein and shall be considered the property of the State. Written permission for the use of these materials in the contractor's operations shall be obtained from the engineer.

(5) Disposal of Temporary Structures, Clearing Sites, and the Like. Upon the completion of the new structures, with the necessary backfilling and roadway embankments, the contractor shall remove and dispose of all temporary structures he may have installed to the satisfaction of the engineer. The adjacent premises shall be placed in such condition as to present neat and acceptable appearances.

(B) Removal of Pipe Culverts and Minor Drainage Structures. All pipe culverts and minor drainage structures, designated for removal, shall be carefully removed and precaution taken to avoid breakage or damage. Pipe culverts to be relaid shall be removed and stored, when necessary, so that there will be no loss or damage before relaying. The contractor will be

required to replace sections lost from storage or damaged by negligence or by use of improper methods.

(C) Removal of Pavement, Sidewalks, Curbs, Etc. All concrete pavement, base course, sidewalks, curbs, gutters, and the like, designated for removal, shall be disposed of as provided herein or otherwise disposed of as directed.

When specified, ballast, gravel, bituminous material or other surfacing or paving materials shall be removed and stockpiled as required; otherwise such materials shall be disposed of as directed.

10.33 METHOD OF MEASUREMENT. When the contract stipulates that payment will be made for removal of structures and obstructions on a lump sum basis, the pay item, removal of structures and obstructions, will include all structures and obstructions encountered within the right-of-way in accordance with the provisions of this section. Where the contract stipulates that payment will be made for the removal of specific items on a unit basis, measurement will be made by the unit stipulated in the contract.

The length of pipe removed will be measured in linear feet, computed by multiplying the number of commercial lengths removed by the nominal laying length, or by measuring in place prior to removal, if practicable.

10.34 BASIS OF PAYMENT. The accepted quantities of removal of structures and obstructions will be paid for at the contract lump sum price, which price shall be full compensation for removing and disposing of the obstructions in accordance with the contract.

Specific obstruction items, including pipe removal, stipulated for removal and disposal under unit price pay items will be paid for at the contract unit price per unit specified in the contract, which price shall be full compensation for removal and disposal, of such items, excavation and subsequent backfill incidental to their removal. The price shall also include salvage of materials removed, their custody, preservation, storage on the right-of-way, and disposal as provided herein, maintenance of traffic and all other operations specified in this section.

When the contract does not contain an item for any aforementioned removal or other work, the work specified will not be paid for directly, but will be considered as a subsidiary obligation of the contractor and the cost absorbed in other contract items. When work required is not set forth in this sub-section it shall be governed in conformity with Section 11.

The item description used in contracts and estimates will be abbreviated by deletion of the word "existing"; e.g. "Remove Structure".

NOTES

SECTION 11

EXCAVATION AND EMBANKMENT

11.01 DESCRIPTION. Roadway, drainage and borrow excavation shall consist of excavating and grading the roadway and borrow pits, including gutters, ditches, channel changes, furrows, parking areas, intersections and approaches, slope rounding, benches on backslopes and benches under sidehill fills; excavation and removal of unsuitable material from the roadbed and beneath embankment areas; removal and disposal of slides; excavating selected material found in the roadway which is ordered for specific use in the improvement; removal and disposal of all unsuitable and surplus material in accordance with the specifications and in reasonably close conformity with the lines, grades, and dimensions shown on the plans or staked by the engineer. Poles for power or communication lines shall not remain on knolls within any excavated areas, unless specifically directed.

11.02 TYPES OF EXCAVATION

(A) Unclassified Excavation. The excavation and specified disposal of any and all material described in Article 11.01 regardless of type or as staked and directed by the engineer. With the exception of areas—originally or finally—categorized as “Subcut Excavation”, if the contract contains no other type of excavation defined in this Section, “Unclassified Excavation” shall cover and include all excavation and disposal described in Article 11.01.

(B) Borrow Excavation

(1) Unclassified Borrow. Material from a borrow area designated on the plans will be furnished by the Department at no cost to the contractor. The contractor may obtain material from a borrow source not shown on the plans providing the location of the source is approved and the quality of material meets the same specifications and requirements as required of the sources furnished by the Department. Approval of the proposed source will require adherence to current environmental regulations. The Department will reimburse the contractor for the cost per cubic yard of obtaining the material from the landowner but in no case shall the reimbursable amount exceed the cost of the Department optioned borrow material. Payment for haul will be in accordance with the provisions of Article 12.12. For contractor furnished

sources, payment for haul may be less than, but shall not exceed the planned quality.

(2) **Special Borrow.** The excavation and placing of materials obtained from accepted sources designated in the plans, stipulated in the contract or from authorized supplementary sources. Generally, "Special Borrow" shall be placed in layers or courses immediately below subgrade surface on embankments and through cuts to such thickness as is specified in the plans or contract. The provisions of Article 11.02(B)(1), shall also apply to "Special Borrow."

(C) **Unclassified Channel Excavation.** The excavation of any and all materials, regardless of type or nature, involved in constructing new water courses or channels or for widening, deepening or straightening existing channels including designated disposal of the material, all in accordance with plans and as staked by the engineer. This type of excavation shall be paid for only when designated by the plans as such and when bid upon by the contractor.

(D) **Street Excavation.** The excavation and removal of any and all material regardless of type, to attain the specified template for city streets or such sections of highway designated on the plans. This type shall be used only when designated and bid upon by the contractor.

(E) **Subcut Excavation.** Subcut excavation shall consist of the removal and disposal of deposits of unstable material from below subgrade elevation in cut sections or from below the natural ground line in embankment sections. Soil may be considered unstable if it contains saturated or unsaturated mixtures of soils and organic matter not suitable for foundation material regardless of moisture content, or if determined unstable by the engineer. Soils will not be classified as subcut excavation if the soils in question can be excavated using the same equipment and procedure as is regularly used for the unclassified excavation on the project.

The subgrade elevation as shown on the plans shall be considered the subgrade elevation for the purpose of sub-cutting unstable materials, however, variations from these planned elevations may be expected. Should the engineer elect to adjust a grade line, the difference between the two grade lines shall not be considered "Subcut Excavation" unless unstable material is encountered at or below the final grade line. Removal of topsoil from below the natural ground line in embankment sections shall not be considered subcut excavation unless the area has been determined unstable.

Removal of unstable materials shall be done in a manner that permits cross-sections or other measurements for volume to be taken before back-filling. The contractor shall not place fill in any area where unstable foundation soils have been excavated until the engineer authorizes him to proceed. Materials placed in violation of this requirement may be ordered removed and replaced at no cost to the Department of Highways.

Subcut Excavation made suitable for embankment material by processing in accordance with Article 11.03(E), will be paid for at the contract unit price for unclassified excavation for the second handling.

11.03 CONSTRUCTION METHODS (EXCAVATION)

(A) Grading

General. The excavation and embankments for the roadway, intersections and entrances shall be finished to reasonably uniform but rough surfaces. Smooth slopes shall be scarified in conformance with Article 17.03. No materials shall be wasted without permission of the engineer. Excavation operations shall be conducted so that material outside of the limits of slopes will not be disturbed. Prior to beginning excavation, grading and embankment operations in any area, all necessary clearing and grubbing in that area shall have been performed in accordance with Section 10.00, Clearance of Right-of-way.

All suitable materials removed from the excavation shall be used insofar as practicable in the formation of the embankments, subgrade, shoulders, topsoiling and at such other places as designated or directed. All excavated material shall be disposed of as directed and no payment will be made for any excavated material which is used for purposes other than those designated.

Material suitable for backfill or road finishing purposes shall be excavated in such sequence that the material can be placed direct in final position on the top portion of the roadbed or as otherwise directed. When this cannot be accomplished, and when so directed, such suitable material shall be stockpiled for subsequent placing in final position as required.

When it becomes necessary to provide temporary fence to restrict livestock and vehicle traffic from the area of construction, such work shall be accomplished in conformity with Article 81.04.

When it becomes necessary to remove any fencing temporarily, the fencing shall be replaced in as good a condition as it was prior to its removal. Fencing damaged by the contractor shall be repaired to the satisfaction of its owner at the contractor's expense. The contractor shall be responsible for the confinement of livestock when a portion of the fence is disturbed.

The top eight inches of the subgrade in cut sections shall be compacted in accordance with Article 11.05. If the contractor elects to use material excavated from the roadway prism for other purposes than embankments, in which cases the contractor shall furnish and place, at his own expense, an amount of borrow, if required, equal to the deficiency caused by the material being used elsewhere.

Excavation which requires more than one handling prior to final placement will be paid for at the contract unit price for unclassified excavation for each handling approved by the engineer or may be paid for as another item of work for the second handling when so specified.

The contractor shall use existing technology in rock blasting and is expected to take advantage of recent developments in the blasting industry to prevent slides, minimize overbreak and provide smooth cut slope faces reasonably free of loose or excessively fractured rock. The ignition sequence and blasting pattern wherever possible should be designed with delays to afford maximum relief to the holes nearest the cut slope face.

(B) Presplitting Rock Backslopes.

(1) Description. Where presplitting is called for in rock cuts that are to be excavated using blasting techniques the following specification shall apply. Presplitting is the construction of a smooth plane in rock by controlled blasting with correct timed explosives chosen for the particular rock and correctly placed in properly aligned and suitably spaced drill holes. Presplitting should cause a continuous or semicontinuous fracture between these drill holes.

The primary objective for presplitting rock backslopes is to produce a smooth face on the rock backslope, that will reasonably conform to the designed lines and grade and that is reasonably free of loose rock. The contractor shall conduct his operations to achieve the stated objectives as nearly as possible without unduly disturbing the rock outside the excavated prism.

The contract quantity of Drill Presplitting Holes is not a guaranteed quantity and the State reserves the right to increase or decrease this item with no adjustment in the contract unit price.

(2) Construction Methods.

(a) Drilling. Drilling shall be done on a reasonably smooth surface of rock. Overburden may have to be removed or the present rock surface prepared to accomplish this end.

The holes for presplitting shall be drilled at intervals of not more than

three feet center to center. An interval of $1\frac{1}{2}$ feet to three feet is generally recommended for trial spacing. The holes shall be from $2\frac{1}{2}$ inches to three inches in diameter. All holes in any cut shall have the same diameter unless otherwise approved by the engineer. The contractor shall vary the spacing of the holes to provide a reasonably smooth face in the material encountered. The hole spacing interval for each cut shall be subject to approval of the engineer before work is begun.

Hole depth shall be limited to a depth in which accurate drilling can be accomplished. The maximum drilling depth shall be limited generally to the depth of the roadway grade elevation unless this depth exceeds approximately 25 feet. The lift depth shall be controlled to prevent hole wander in excess of nine inches from neat lines. Cut sections with depths in excess of 25 feet may require presplitting in two or more lifts. The cut depth to each presplit lift will be determined by the engineer.

The bottom of the primary blast holes shall not be lower than the bottom of the presplit holes for each lift or blast conducted in rock cuts.

Presplitting accomplished in two or more lifts, shall have not more than a one foot offset provided on each lift before presplitting the next lift. The proper adjustments in equipment or methods shall be made to insure that the faces of backslopes are parallel when more than two lifts are required.

The primary blasting holes nearest the presplit face shall at no point be closer than four feet from the presplit face. This distance may be widened at the direction of the engineer to prevent overbreakage. Primary blasting holes shall be loaded in a manner and quantity to minimize overbreakage.

Permission to blast in rock cuts, where presplitting is specified may be granted prior to presplitting for removal of small knobs and rock overburden as preparation for the area to be drilled; or for primary blast excavation to be conducted a considerable distance from the presplit face and which will not damage the presplit face. Permission to blast without the planned presplit shall require the contractor to submit written acceptance of responsibility for the cost of corrective measures that would extend beyond the planned cut-slope including specified tolerances.

(b) Blasting. The explosives used in presplitting shall be used with care. The quantity and manner of use shall be such that overbreak is negligible, that seams in the backslope rock are not opened and that the backslope rock is not fractured excessively.

The explosive used shall be from one-tenth to three-fourths of a pound of 40 percent extra strength dynamite per linear foot of hole or other equivalent explosive charge that shall produce equally satisfactory results. The recommended charge is one-quarter lb. of 40 percent extra

strength dynamite per linear foot. The charges shall be prepared by taping fractional portions of standard explosive cartridges to a length of detonating fuse or by other approved method which results in equivalent explosive density. Fuse length shall be as long as the drill hole is deep. A detonator of suitable strength shall be used with each explosive, especially if explosives other than 40 percent extra strength dynamite are used.

Charges, attached to a detonating cord, shall be uniformly spaced and evenly distributed throughout the length of the hole. A charge of no more than two pounds of dynamite shall be concentrated at the bottom of each hole, one pound is the recommended load. The top charge shall be not less than 2½ feet or more than three feet from the collar. The charges in each hole shall be spaced at intervals of approximately twelve inches center to center. The charges in adjacent holes shall be staggered. The engineer may require a change in the size and spacing of the individual charges in each cut. A reduction of the charge, up to 50 percent, may be made in the upper portion of the hole to control overbreak near the top of a slope if overbreak has occurred in previous blasts.

Stemming material shall be dry. It shall pass a three-eighths inch standard sieve and may be clean stone chips, sand or drill cuttings. Stemming shall be required the full depth of hole in badly fractured rock. Stemming shall be required in the top three feet only of holes drilled in sound unfractured rock.

Each presplitting charge in any blast shall be exploded at the same time. The presplitting holes shall be shot at least 100 milli-seconds and completed prior to any other blasting within 50 feet of the longitudinal limits within which all presplitting is to be accomplished. Presplitting holes shall be shot within one day after they have been loaded. No holes charged shall be left unattended.

Blasting shall be done in a manner to provide a presplit backslope that does not vary more than nine inches from the line of drill holes. When blasting in badly broken rock, rock with excessively large seams or rock where unavoidable irregularities will occur, it may be necessary that holes for presplitting be drilled and fired before primary holes are drilled.

(c) Rock Excavated Below Grade. Rock, hard sandstone, shale or other unyielding materials which cannot be excavated without blasting or the use of rippers when encountered in cuts, shall be excavated to a minimum depth of six inches below subgrade within the limits of the roadbed, unless otherwise specified. The excavated area shall be backfilled with material designated on the plans or approved by the engineer. Undrained pockets shall not be left in the surface of the rock material.

Rock removed to a maximum depth of six inches below subgrade will be measured and paid for at the contract unit price. The backfilling of this depth in excess of six inches with backfill material designated on the plans or approved by the engineer will be at the expense of the contractor.

(d) Excessive Moisture. Soil for the finished roadbed made unsuitable, by excessive moisture introduced or caused by construction operations shall be made suitable when directed, and re-used in the work at no cost to the State. Excessively wet but otherwise suitable material may be directed to be removed and replaced with suitable materials, at no cost to the State.

(e) Removal of Excess Moisture. When materials from excavation or borrow areas contain moisture in excess of two percent above the required optimum moisture value to conform to the percent of maximum density requirements specified in Article 11.05, such materials shall not be placed in embankments or as backfill until such excess moisture has been removed therefrom. The method of removal of excess moisture shall be the option of the contractor. Regardless of circumstances and regardless of method, any and all costs involved in the removal of excess moisture from the material will be understood to be covered and included in the price or prices bid for one or more of the contract bid items related to earth work.

(f) Borrow Material. Borrow material should not be placed until after the roadway excavation has been placed in the fill. If the contractor places more borrow than is required and thereby causes a waste of excavation, the amount of such waste will be deducted from the borrow volume as measured in the borrow area. All borrow areas shall be finished and left in such shape as to permit accurate measurements after excavating has been completed. The contractor shall notify the engineer in sufficient time before beginning excavation that the necessary cross sections may be taken. The contractor shall not excavate beyond the dimensions and elevations established, and no material shall be removed prior to the staking out and cross-sectioning of the site. The finished borrow areas shall conform to the requirements of Article 06.02(E).

(g) Sloping. To facilitate topsoiling, the slopes of all cuts, ditches, embankments and structure berms shall be finished to a reasonably uniform but rough surface. Smooth slopes shall be scarified.

When there is a transition from excavation to embankment, and the natural ground slope is greater than 6:1, additional excavation shall be

performed by benching so that no natural ground surface will remain closer than twelve inches to the top of subgrade.

Where roadway slopes have been completed by the contractor to the lines originally staked or established by the engineer, and the material from such slopes sloughs, erodes or slides from back of the established slopes onto the roadway prism before final acceptance of the work and through no fault of the contractor, the removal of such slide, slough, erosions, overbreak and potential slide material and additional excavation necessary to provide drainage across the area will be paid for at an agreed unit price or on a force account basis as provided for in Article 04.03.

When so directed, cuts shall be uniformly widened and slopes flattened where necessary, to obtain additional excavation for embankments or to increase stability of slopes. When rock is encountered, where slopes will stand at a steeper slope than shown in the plans, the slopes shall be steepened when directed.

When the flattening or widening operations require no changed construction procedure from the adjacent grading operations the work will be measured and paid for as unclassified excavation.

Where the additional widening requires changed construction methods which result in an increased cost to the contractor over that originally contemplated in the contract, such as placing sliver fills or excavating sliver cuts, the work will be considered extra work as specified under Article 04.03.

(h) Shaping. After all earthwork has been substantially completed, all structures are complete, and all drains are laid, the entire surface of the roadbed shall receive a finish shaping with appropriate equipment, supplemented by hand work where necessary, to secure a smooth surface and uniform cross section. Rock sections and all other sections, where the natural material is not considered suitable, shall be brought to grade by depositing, to the depth authorized, a satisfactory cushion of selected material.

(i) Finishing. The entire roadbed shall be brought to the final elevation and shape indicated on the plans and dressed as directed. No roots, sod, or other deleterious matter, shall be left within the top four inches of the finished roadbed surface. Oversize material, either loose or partly buried, that will not pass a four-inch square mesh screen shall be removed from the entire surface of the roadbed and shall be disposed of as directed. The finished grade shall not deviate more than one-tenth foot at any point from the staked elevation and, provided further, that the sum of

the deviations from true grade of any two points not more than 30 feet apart shall not exceed one-tenth foot.

(j) Maintenance of Constructed Roadway. During construction the roadway shall be maintained in such a condition that it will be well drained at all times. Side ditches or gutters emptying from cuts to embankments shall be co constructed as to avoid damage to embankments by erosion. The contractor shall maintain, and keep open and free from leaves, sticks and other debris, all ditches constructed by him until final acceptance of the project.

If it should become necessary, because of weather or other conditions, to suspend grading operations the entire area worked upon shall be bladed smooth, free of depressions and ruts and crowned so that no water can collect or be impounded on the roadway.

Embankments constructed to grade and cross section during the winter shall be refinished to grade and cross section after the frost is out of the ground and the embankments are in suitable condition for this work.

(k) Artifacts. When the contractor's excavating operations encounters remains of prehistoric people's dwelling sites or artifacts of historical or archeological significance, the operations shall be temporarily discontinued until notified by the engineer. The engineer will contact archeological authorities to determine the disposition thereof. When directed by the engineer, the contractor shall excavate the site in such a manner as to preserve the artifacts encountered and shall remove them for delivery to the custody of the proper state authorities. Such excavation will be considered and paid for as extra work.

11.04 EMBANKMENT CONSTRUCTION.

(A) General. Embankment construction shall consist of constructing roadway embankments, with approved materials, including preparation of the areas upon which they are to be placed; the construction of dikes within or outside the right-of-way; the placing and compacting of approved material within roadway areas where unsuitable material has been removed; and the placing and compacting of embankment material in holes, pits and other depressions within the roadway area. Suitable material shall be secured from designated roadway and drainage, structure, culvert or borrow excavation in conformity with the lines and grades and locations shown in the plans and as directed.

Stumps, trees, logs, rubbish, vegetation or other unsuitable materials shall not be placed in embankments. Sod mixed with surface soil and soil containing large amounts of humus or other organic materials shall be

spread over the embankment slopes or incorporated in the embankments outside of the shoulder lines. Pockets of rock or muck will not be permitted. Frozen material shall never be placed in embankments.

Compaction of embankments, including backfilling and preparation of embankment foundation areas, shall meet the requirements of Article 11.05, unless otherwise specified.

(B) Embankment at Structures. Rocks, broken concrete, or other solid materials shall not be placed in embankment areas where piling is to be placed or driven.

If embankment can be deposited on one side only of abutments, wing walls, piers or culvert headwalls, care shall be taken that the area immediately adjacent to the structure is not compacted to the extent that it will cause overturning of, or excessive pressure against, the structure. When noted on the plans, the fill adjacent to the end bent of a bridge shall not be placed higher than the bottom of the back wall of the bent until the superstructure is in place.

Embankment and backfill shall be placed in layers of eight inches or less loose thickness and compacted adjacent to structures, around columns and similar structural supports, on both sides of concrete walls, box type structures and similar structures. Backfill material placed within the excavation limits shall be compacted. Backfill material placed above the excavation limits or ground line shall extend at least ten feet from the structure or structural support and be compacted. Structures or structural members that have moved or become distorted as a result of placing embankment shall be adjusted, repaired and restored by the contractor at no cost to the Department.

Embankment at structures and especially areas inaccessible to rollers shall be compacted by mechanical tampers or other means until the density conforms to that specified under Article 11.05, provided however, that for embankment other than at structures, the compaction required shall not exceed that of the adjacent embankment, compacted in accordance with these specifications.

The ground upon which the backfill is placed shall be compacted to a density of at least 90% Montana Test Method M. T-210, by rolling or mechanical tamping to a depth of at least eight inches.

(C) Construction Methods.

(1) Preparation of Embankment Foundations. When embankment is to be placed and compacted on hillsides, or when new embankment is to be compacted against existing embankments, or when

embankment is built one-half width at a time the slopes that are 4:1 or steeper when measured at right angles to the roadway shall be continuously benched over those areas where it is required as the work is brought up in layers. Benching shall be of sufficient width to permit operations of placing and compacting equipment.

Each bench shall be cut as close to the one below as the ground slope will permit. Acceptable material cut out of benches shall be incorporated into the new embankment. The contractor will not be paid for excavation less than one half the width of standard equipment. Payment will be made for excavation greater than one half the width of standard equipment.

Where embankment is to be placed and compacted and end dumping is permitted, the slopes of the original ground or embankment shall be deeply plowed or cut into before starting end dumping.

Where embankment of less than four feet below subgrade is to be made, all sod and vegetable matter shall be removed from the surface upon which the embankment is to be placed and the cleared surface shall be completely broken up by plowing, scarifying or stepping to a minimum depth of eight inches. The area shall then be recompact until a relative compaction of 90 percent, as determined by Montana Test Method M.T. - 210 is reached in these eight inches.

Whenever the surface of a cut or the site of an embankment is covered with snow or ice, sufficient to impair the stability of the work, the snow and ice must be removed and deposited beyond the slope stakes at the contractor's own expense. Work of this nature shall be completed at least 300 feet in advance of the excavation and placing of the embankment material. Frozen excavation or that lying under a blanket of snow of such extent as to preclude its placement in the embankment will be considered cause for suspending grading operations.

Where embankments are to be placed on soils have a relative compaction of less than 90 percent determined by Montana Test Method M. T.-210, or equivalent methods, the ground surface shall be scarified, watered and compacted before placing embankment material until a relative compaction of at least 90 percent is reached in the upper eight inches of the compacted soil. The width of the above treatment shall be that of the Subgrade (as defined in Article 1.58) as a minimum and more when directed by the engineer, dependent upon ground conditions. Should lightly compacted soils be encountered that extend to depths greater than eight inches, the upper portion thereof between fill stakes shall be removed to the depth ordered by the engineer, after which the ground surface shall be compacted until a relative compaction of ninety percent is reached in the upper eight inches.

Material removed, as herein provided, shall be placed in embankment directly from excavation or used for topsoil as directed by the engineer. Material suitable for topsoil may be placed alongside the roadway section and placed thereon after compaction operations have been completed.

Whenever a compacted road surface lies within three feet of the subgrade, such old road surface shall be scarified to a depth of at least eight inches. This scarified material shall be recompacted until a relative compaction of 90 percent is reached.

(2) Earth Embankment. Roadway embankment of earth material shall be placed in horizontal layers not exceeding eight inches (loose measurement) and shall be compacted as specified before the next layer is placed. Effective spreading equipment shall be used in each lift to obtain uniform thickness prior to compacting. As the compaction of each layer progresses, continuous leveling and manipulating will be required to assure uniform density. Water shall be added or removed, if necessary, in order to obtain the required density. Construction equipment shall be routed uniformly over the entire surface of each layer.

(3) Rock Embankment. When the excavated material contains more than 25 percent by volume of rock larger than six inches in greatest dimension it shall be placed in the embankment, in layers of sufficient depth to contain the maximum size rock present in the material; provided, however, that in no case shall the thickness of layers before compaction exceed 24 inches.

Even though the thickness of layers is limited, as provided above, the placing of individual rocks and boulders greater than 24 inches in diameter will be permitted provided that, when placed, they do not exceed 48 inches in vertical height and provided they are carefully distributed with the clearance between adjacent fragments sufficient to provide adequate space for filling and compacting in horizontal layers as specified.

Under all conditions, the upper portions of the embankment, for a depth of at least two feet, shall be composed of suitable material smoothed and placed in layers not exceeding eight inches in loose thickness and compacted as specified for embankments.

Rock encountered in excavations shall be dumped and worked to the stream face of embankments, when these embankments are adjacent to streams or channels. The cost of this work shall be absorbed in the unit price bid for unclassified excavation.

(4) Embankment Over Swampy Areas. When embankment is to be constructed across low swampy ground that will not support the weight

of hauling equipment, the lower part of the fill may, if approved by the engineer, be constructed by dumping successive loads of material in uniformly distributed layers of a thickness not greater than necessary to support the hauling equipment while placing subsequent layers in the previously specified standard manner.

(5) Unsuitable or Excess Material. All excess or unsuitable excavated material, including rock and boulders, that cannot be used in embankments may be placed in the side slopes of the nearest fill in a satisfactory manner and shall be placed so as to maintain a distinct shoulder line by keeping all such waste material the specified distance below the finished shoulder line elevation. In case it is impossible to dispose of all such material in the manner described, the remainder shall be disposed of as directed. All disposal areas shall be left with a pleasing appearance.

11.05 MOISTURE AND DENSITY REQUIREMENTS. Each layer of roadbed material shall be compacted, with the proper use of water, until the in-place density of the material being compacted is not less than 95 percent of the maximum density established for the material being compacted or the material source or both. Water required shall be sufficient to obtain optimum moisture content plus or minus two percentage points, as determined by Montana Test Methods, unless modified by the engineer for conditions applicable to the character of the material being tested.

Material tests used to establish the maximum density values will be performed in accordance with Montana Test Method MT-210, or AASHTO-T-99. In-place density and moisture testing will be performed in accordance with applicable Montana Test Methods MT-212, MT-215, & MT-218. The percent compaction will be determined after making proper adjustments, when necessary, for oversize material.

Each layer of roadbed material that cannot be properly tested by Montana Test Methods, MT-212, MT-215, & MT-218, shall be compacted with compaction equipment in addition to compaction by hauling and spreading equipment. Compaction equipment for rocky material that cannot be tested shall normally be grid rollers, pneumatic-tired rollers, vibrating rollers, vibrating compactors, or self-propelled tamping rollers. Sheepfoot rollers shall not be used unless specifically directed. Water shall be used where directed.

11.06 TOPSOIL-SALVAGING AND PLACING.

(A) General. When directed by the engineer, where suitable topsoil material is available, within areas to be excavated and area upon which

the embankment is to be placed, the contractor shall remove such material to a depth specified by the engineer. The material removed shall be stockpiled for later use as herein specified for covering as directed by the engineer. Normally back slopes will be given preference in placing topsoil material. The plans will indicate the approximate quantity of topsoil.

(B) Construction Methods. In no case shall topsoil material be placed on any section before the roadway grading has been completed to the lines, grades and elevations set forth on the plans approved by the engineer. It shall not be placed above the sub-grade of the roadway inslopes and on slopes steeper than 2:1. Unless otherwise specified, topsoil shall be placed to an average loose depth of four inches.

In the work of removing topsoil, care shall be taken to avoid the incorporation of any appreciable amount of sub-soil.

Topsoil excavated, from the areas designated, shall be stockpiled at any location, within the right of way selected by the contractor, and approved by the engineer, which will not impair drainage and so that it can be reclaimed and spread on the designated areas.

Where operations of the contractor do not permit stockpiling within the regular right of way, it shall be the contractor's obligation to arrange for necessary stockpile sites, approved by the engineer, outside of the right of way at his own expense.

11.07 METHOD OF MEASUREMENT.

(A) Excavation. Payment for excavation quantities will be made in accordance with Section 09.01 unless otherwise specified.

All accepted excavation and borrow shall be measured in its original position by cross-sectioning the area excavated, such measurements will include unclassified excavation, overbreakage and slides, not attributable to carelessness of the contractor, and authorized excavation of rock, shale, muck or other unsuitable material. Volumes will be computed from the cross-section measurements by the average end area method.

The measurements will include overbreakage in rock excavation from the backslopes to a quantity not to exceed in any half station of 50 feet, ten percent of the actual quantity within that half station.

Drill presplitting holes will be measured by the linear foot. Measurement will include the explosive charge, detonators and stemming. The measurement will be made from the rock surface to the roadway grade, or to a predetermined bench elevation.

Where the contract does not specifically provide for payment for

embankment, the work of embankment construction will not be paid for as such but will be considered incidental to the various classifications of excavation.

Authorized excavation of rock, shale, muck or unsuitable material below grade shall consist of that excavation necessary to provide the designed thickness of backfill. If the plane of the designated bottom of excavation falls within a layer of stratum rock, the below-grade excavation to the bottom of the layer, not exceeding six inches below grade, will be considered as authorized and will be measured for payment. Rock excavation more than six inches below grade will not be paid for. If the nature of the material, the thickness of the layers or strata and method of operations are such that it is practical to excavate only to the depth shown on the plans, no measurement will be made of any material removed below the line designated.

Where it is impractical to measure material by the cross-section method, acceptable methods involving three dimensional measurements may be used.

Measurements will be made for unsuitable materials actually excavated and removed.

No measurement will be made of the suitable material temporarily removed and replaced for the contractor's convenience.

Excavation to be used as selected material or stockpiled as such shall be measured by the cubic yard in its original position. When removed from the stockpile and placed as directed, it shall again be included for measurement according to the volume in its original excavated position.

Unless otherwise specified, "Clearance of Right-of-Way" (Section 10) within the limits of the work shall be considered as incidental to and necessary to performance of roadway, drainage and borrow excavation and shall be performed at the contractor's sole expense.

(B) Compaction.

(1) Unit Measurement. When stipulated in the contract "watering" and "rolling" required under this construction method will be measured according to the contract unit prices.

Water used and approved by the engineer will be measured as described in Section 13.

Rolling will be paid for in accordance with the provisions of Section 13.

(2) Volume Measurement. When "Roadbed Compaction" is specified in the contract as an item, the quantity or volume to be paid for shall be the actual yardage of unclassified excavation incorporated in the roadway excluding material wasted. Measurement will be in accordance

with Article 11.07, part (A). Road approaches, turnouts, wyes, and other such facilities shall be included as part of the roadway. Measurement will also include compaction of the natural ground in accordance with Article 11.04(C)(1) and compaction in cut sections in accordance with Article 11.03(A)(1).

Water required to obtain specified moisture content will not be measured for payment. Rolling and other compactive effort will be included in the price for "Roadbed Compaction."

(3) No Bid Item For Compaction. When the contract does not contain an item covering compaction, all work and materials necessary to compact embankment material to the specified density will not be paid for separately, but will be considered to be a part of and absorbed in the contract unit price for Unclassified Excavation or Unclassified Borrow Excavation.

(C) Structure Backfill. Compaction of structure backfill and at ends of major structures will not be measured for payment unless there is an item for mechanical tamping. If mechanical tamping is an item, then such work will be measured by the cubic yard of backfill material; plus compaction of the ground upon which it rests to a depth of eight inches where such compaction is required.

(D) Measurement of Water. When payment for water is specified in the contract, the water used in the work will be measured by the M-Gal. (1000 gallons) by means of calibrated tanks or distributors or by means of accurate water meters.

When water is not specified as a pay item in the contract, the water used will not be measured or paid for but will be incidental to the work.

(E) Topsoil. Excavation of topsoil material from its original position, stockpiling and later removal of the topsoil material from the stockpile and spreading upon the designated areas will be measured for payment by the cubic yard, in the stockpile prior to removal of the material for final placement. Prior to measurement each stockpile shall be shaped and smoothed into as small an area as is practical. Haul will not be measured.

11.08 BASIS OF PAYMENT.

(A) Excavation, Embankment and Compaction. Embankment construction will not be paid for directly, unless specified otherwise. It shall be considered a necessary part of the work, and included in the unit price bid for all excavation required to construct the embankment. The contract unit price for excavation shall include all labor, tools, equipment

and other incidentals necessary to place, level, manipulate, dry the embankment material, plow hillsides, cut into old fills, to scarify old roadway and perform other work necessary for proper embankment construction. This contract unit price shall include all costs incidental to completing the work in accordance with the specifications.

Special borrow will be paid for at the contract unit price for all special borrow used in the accepted and completed work, which price and payment will be full compensation for the work. No payment whatever will be allowed the contractor for removal and disposal of unsuitable materials from borrow areas, nor will payment be allowed for special borrow removed from areas prior to the staking or cross-sectioning thereof.

The cost of removing and drying or replacing soil made unsuitable by excessive natural moisture will be paid at the contract unit price for unclassified excavation.

When "Subcut Excavation" is specified in the contract as a bid item, the volume to be paid will be the actual yardage of subcut excavation removed and will be paid for at the contract unit price. The contract unit price shall apply to all areas designated as unstable on the plans or as determined to be unstable by the engineer. Payment for hauling subcut excavation to the designated disposal areas, or for disposal as otherwise directed, will be made at the contract unit price for "Haul."

When the contract does not contain the item "Subcut Excavation" and the engineer determines an area to be unstable according to the conditions stipulated in Article 11.02(E), the quantity of subcut excavation to be paid for will be paid on an agreed price or force account basis as provided in Article 09.04. Payment at the agreed price shall include compensation for all excavating and hauling, disposing of all stumps, logs and other debris encountered in the excavation, for all pumping and dewatering specifically required and for all finishing of the planned disposal areas.

When stipulated in the proposal "rolling" and "watering" required under the "Unit Measurement Method," will be paid for at the contract unit price in accordance with Section 13.

When the proposal specifies that embankments and roadbed shall be constructed in accordance with the "Volume Measurement Method" and provides an item for "roadbed compaction" by the cubic yard, payment shall be made in accordance with the following provision. "Roadbed Compaction" shall be paid for at the contract unit price per cubic yard. This price and payment shall be full compensation for all compactive effort necessary to obtain the densities specified for furnishing all equipment, compacting effort, scarifying, watering, aeration manipulations and other

work required to produce the specified finished roadbed and embankments.

(B) Drill Presplitting Holes. This item will be paid for at the contract unit price per linear foot for the accepted footage of Drill Presplitting Holes. This price and payment shall be full compensation for drilling, loading, stemming, detonating and all materials, equipment, tools, labor and incidentals necessary to complete the item.

(C) Water will be paid for by the unit of 1000 gallons provided by Section 13 when bid as a separate item.

(D) Rolling will be paid for by the unit, as provided by Section 13, only when rolling is a contract item and embankments are built by the Unit Measurement Method.

(E) Topsoil. Topsoil, measured as specified, will be paid for at the contract unit price per cubic yard for "salvaging and placing topsoil."

The price and payment for topsoil shall be full compensation for all excavation, loading, hauling, stockpiling, spreading and for all labor, equipment, tools and incidentals necessary to complete the work.

Topsoil removed from roadway cut areas will not be deducted from the Unclassified Excavation, Roadbed Compaction or Haul quantities. Payment will be made as if the topsoil material had not been removed.

Topsoil removed from embankment areas prior to placing embankment will not be considered for payment as Unclassified Excavation, payment will be made for - Topsoil, Salvaging and Placing - only.

Topsoil removed from Borrow Areas, which will be stockpiled and used as topsoil to reclaim the borrow site, will not be considered for payment as Unclassified Borrow Excavation. Payment will be made for - Topsoil, Salvaging and Placing - only. No separate payment will be made for Topsoil Salvaging and Placing on contractor furnished borrow areas in conformance with Article 06.02(E)(4).

The quantity of topsoil shown on the plans is not guaranteed to be required or used. The Department reserves the right to increase, decrease or omit any portion or all of the item and no additional compensation will be allowed by reason thereof.

(F) Mechanical Tamping will be paid for by the cubic yard only when it is a contract item.

(G) Obliteration. When not included in the proposal as a contract item, roadway obliteration will be paid for as excavation unless otherwise specified.

(H) **Payment.** Payment will be made under:

Pay Item	Pay Unit
Drill Presplitting Holes.....	Lineal Foot
Embankment in Place	Cubic Yard
Roadbed Compaction	Cubic Yard
Special Borrow	Cubic Yard
Street Excavation	Cubic Yard
Subcut Excavation	Cubic Yard
Topsoil, Salvaging & Placing.....	Cubic Yard
Unclassified Borrow Excavation	Cubic Yard
Unclassified Channel Excavation.....	Cubic Yard
Unclassified Excavation	Cubic Yard

NOTES

SECTION 12

HAUL

SUBSECTION 12.10 HAUL.

12.11 DESCRIPTION. Haul shall consist of the transporting of the material obtained as excavation from its original location to its final location in the work.

12.12 METHOD OF MEASUREMENT. In determining what constitutes authorized haul, it will be assumed that material taken from excavation will be deposited in adjacent embankment after having been hauled the minimum possible distance. The haul distance for material moved from outside the roadway shall be measured along the shortest route determined by the engineer to be feasible and satisfactory. The haul distance for material obtained from the roadway and placed inside the roadway shall be measured along the centerline of the roadway to the nearest one-tenth of a mile.

Haul shall be the product obtained by multiplying the number of units of excavation removed from its original position by the mean distance such excavation is hauled. The distance between the center of volume of the excavation and the center of gravity of the embankment shall be the haul distance in the units specified.

Excavation and embankment volumes for ramps, frontage roads, road approaches, driveways and connections on either side of the roadway will be considered as concentrated at the centerline, or a line parallel with the main roadway under construction, for computing haul quantities for payment.

The number of cubic yards of materials hauled will be determined by measurement of the materials in their original position with no allowances being made for any swell that may occur when the materials are excavated and loaded into the trucks or other conveyances.

When "Unclassified Borrow" or "Special Borrow" excavation, as set forth in article 11.02 (B) is called for and an available source is indicated on the plans, the contractor is not restricted to the source shown, but actual haul will be measured and paid for in conformity with these specifications, regardless of source, but in all cases haul will be limited to the quantity of mile-yards shown on the plans. Any haul over and above this amount will not be measured or paid for.

12.13 BASIS OF PAYMENT. The quantity of haul measured as provided above will be paid for at the contract price. Units of measurement will be as tabulated below.

Pay Item	Unit of Quantity	Units of Distance	Pay Unit
Haul	Cubic Yard	Miles or fractions of miles	Mile Yards

When it is specified that haul will not be paid for separately on some items of work, it will not be measured and paid for if the material can be secured and used as shown on the plans. Should changes from the plans cause an increase in the necessary haul, payment will be made for such increase at the contract price. In case no contract price for haul has been established in the contract, increased haul costs will be paid for as extra work.

SUBSECTION 12.20 AGGREGATE HAUL.

12.21 DESCRIPTION. When so provided by the contract, aggregate haul will be paid for the transporting of various surfacing materials.

12.22 METHOD OF MEASUREMENT. Aggregate haul will be measured by the ton mile or cubic yard mile for haul of acceptable aggregate over an approved route. The number of ton miles or cubic yard miles will be the product of miles times tons or cubic yards. The haul distance will be measured to the nearest one-tenth mile along the shortest practicable route from the loading point to the point of deposition.

The estimate for haul set up in the contract is based on a haul distance from the State optioned source to the point of deposition. The haul distance estimated for the State optioned source will be used for contractor selected sources having a longer haul route. The haul distance for contractor selected sources having a haul route shorter than the estimated route will be the distance traveled along the shorter route.

12.23 BASIS OF PAYMENT. Aggregate haul, when so provided by the contract, will be paid for at the contract unit price, which price and payment will be full compensation for the work.

When not stipulated, by the contract, haul of any material will not be paid for directly but shall be considered incidental and necessary to the performance of and payment for the other contract items and shall include everything necessary to complete the work.

SECTION 13

ROLLING AND WATERING

SUBSECTION 13.10 ROLLING.

13.11 DESCRIPTION. Rolling shall consist of the operation of various specified types of rollers as required for compaction of embankment foundations, embankments, subgrade, aggregate surfacing, bituminous courses and cover aggregate, in reasonably close conformity with these requirements and the specifications for the particular type of work involved.

13.12 EQUIPMENT. The types of rollers specified for the particular work shall in general meet the requirements of the following:

(A) Weights. Weights of the rollers shall be based on the manufacturer's rating or recommendation. Self-propelled rollers shall be powered adequately for the efficient accomplishment of the specified work and capable of reversible operation, devoid of backlash. They shall be in good mechanical condition and provided with positive accurate steering control. Pull type rollers shall be towed with truck or tractor power capable of efficient operation. Roller operation shall be separate and distinct and, other than with required traction units, rollers shall not be operated in combination with other equipment. All types of rollers shall be equipped with self cleaning devices to prevent adhesion of materials to the wheels or tamping surfaces. Each and every roller or compacting equipment proposed by the contractor for use on the project, shall be of standard manufacture and subject to the approval of the engineer, it must bear an identifying number, letter or symbol, legibly affixed thereto by the contractor.

(B) Metal Wheeled Rollers. Metal wheeled rollers shall be smooth wheeled and self propelled, with the exception of (3) below.

- (1) Tandem type weighing up to ten tons.
- (2) Three wheeled type weighing not less than ten tons.
- (3) Towed steel-drum rollers weighing not less than four tons.

(C) Tamping Rollers. Tamping rollers shall consist of metal rollers, drums or shells, surmounted by metal studs, pads or similar contrivances which serve to compress relatively small areas of soil

(D) Pneumatic-Tired Rollers. Pneumatic-tired rollers shall be two-axle type, straight or oscillating, mounted in a rigid frame and provided with a platform or body suitable for ballast loading and having an effective rolling width of not less than four feet. A pneumatic-tired roller shall have a minimum working weight capacity of 250 pounds per inch width of tire tread. The tires shall be smooth (no tread) and of equal size and diameter. The tires on the rear axle shall be so spaced that the entire tread gap of the preceding two tires will be covered by the tread of the following tire. They shall be uniformly inflated and the air pressure in the several tires shall not vary from each other more than five pounds per square inch.

The roller shall be capable of turning in such manner that the material being rolled or the adjacent roadbed shall not become dislodged or loosened. Depending upon specifications for the particular type of work, the roller may be self-propelled or drawn by either suitable tractor or truck of adequate tractive power. Use of wobble wheeled pneumatic-tired rollers will not be permitted on bituminous surfacing work.

(E) Other Types of Rollers. Other types of rollers, of general standard manufacture, such as Grid Rollers, various types of vibrating rollers, and other types which will obtain satisfactory compaction in acceptable time as a general rule, will be satisfactory.

13.13 CONSTRUCTION METHODS.

(A) General. Each layer of surface course or each layer of embankment where compaction is required shall be completely compacted by rolling, and watering if necessary, before the succeeding course or layer is placed. Rolling shall be extended completely across the roadway commencing at the sides and progressing toward the center, overlapping each preceding passage by approximately one-half the width of the roller. On superelevated curves, rolling shall begin at the low side and progress toward the high side.

All types of rollers, excepting vibrating types and operations in confined areas, shall be operated at a minimum speed of two miles per hour. Maximum speed for tamping and grid rollers shall be 15 miles per hour and for pneumatic-tired rollers seven miles per hour. Vibratory rollers shall be operated at speeds between $1\frac{1}{2}$ and $2\frac{1}{2}$ miles per hour. Operations in confined and small areas will be governed by conditions as determined by the engineer.

Along curbs, headers and walls and at all places not accessible to the rollers the area on any type of surface shall be compacted thoroughly by acceptable mechanical or hand tamping methods.

(B) Compaction of Roadbed. Where compaction of embankments and subgrades by rolling is specified, the rollers used shall meet the requirements of Article 13.12. The specified type to be used will be governed by the type of material being compacted and by conditions. The requirements of Article 11.05, shall govern.

(C) Compaction of Aggregate Surfacing. Compaction of any type of aggregate surfacing shall be accomplished by the coordinate use of the type of rollers specified in Article 13.12 and in accordance with the provisions of Section 20.

(D) Compaction of Bituminous Surfacing. Compaction of bituminous surfacing shall conform to the requirements of the following:

(1) Road Mix—See Section 33

(2) Plant Mix—See Section 30

(3) Bituminous Surface Treatment and Seal Coat—See Section 32 and 34 respectively.

13.14 METHOD OF MEASUREMENT. Rolling will be measured in units based upon width of roller track or tracks upon the ground, the operating weight of the roller and the length of time it operates. Hours will be recorded to the nearest one-half hour. The summation for payment will be carried to the nearest tenth of a unit.

One unit will be allowed for a roller having a rolling width between 120 and 125 inches, an operating weight between 10 and 12 tons, operated on a designated area for one hour. The unit value will be increased as the weight increases and also as the rolling width decreases. See Table II, at the end of this section, for determining Unit Values.

The width of roller track, in the case of a single drum roller, would be the measured width of track; for a roller, such as a two wheel steel roller, would be the width of front track plus the width of the rear track. See Table I, at the end of this section, for illustrations and more definite instructions.

The operating weight of the roller is that weight which actually prevails at the time of use, determined by adequate scales. If the roller is not ballasted to obtain extra weight, the manufacturer's rated weight may be considered for acceptance.

The time or hours of operation of the roller will be multiplied by the appropriate unit value shown in Table II.

The number of hours used in determining payment for rolling will be the number of hours actually consumed in rolling.

No deduction in time will be made because of minor rolling delays caused by conflicting roadway operations.

Time consumed in servicing the roller or in making more than minor operating adjustments, or in moving to and from the actual work, will not be measured for payment.

The number of rolling units stipulated in the contract is an estimated quantity. The Department reserves the right to use and pay for the amount considered necessary to do the work.

13.15 BASIS OF PAYMENT. Rolling used in the completed and accepted work will be paid for at the contract unit price, which price and payment, except as otherwise expressly provided, will be full compensation for all operations necessary to complete the work.

When rolling is specified as being necessary, but not included in the contract as an item, it will not be paid for directly but will be considered incidental to and absorbed in payment for the other items of the contract.

SUBSECTION 13.50 WATERING.

13.51 DESCRIPTION. "Watering" shall consist of furnishing and applying water as required in the compaction of embankments, roadbeds and surfacing materials, in accordance with the requirements of the specifications.

13.52 CONSTRUCTION METHODS.

(A) Watering, Embankments, Roadbeds and Surfacing Aggregates. Water, when required, shall be applied on the areas and in the quantities and at the times directed by the engineer. The contractor shall furnish and operate water applying tanks, equipped with spray bars, for use on embankments, subgrades and surfacing. They shall be mounted on pneumatic-tired trucks or pneumatic-tired trailers pulled by pneumatic-tired equipment. The minimum capacity of any water distributing tank shall be 1,000 gallons. The water distributing equipment shall be constructed to provide and assure accurate and uniform distribution of the required rates of water per unit of surface area. The control valves shall be constructed to permit positive closing and to prevent leakage.

Sufficient equipment shall be available at all times to apply the amount of water required within the time interval necessary to secure proper results before evaporation, absorption, or drainage prevents or interferes with the required results. When directed by the engineer, watering may be

done at night or at other times to minimize losses by evaporation, absorption or drainage.

(B) Water for Maintenance of Traffic and Detours. In the maintenance of traffic and detours, watering shall be performed at any hour of the day and on any day of the week that the engineer may determine as necessary for proper performance or protection of the work and for adequate alleviation of dust nuisance.

(C) Pre-wetting Excavation Areas. The contractor may, in lieu of or in addition to the methods provided by Part "A", pre-wet the material in excavation areas prior to removal and placement in embankment.

The soil shall be moistened by sprinkler irrigation. The excavated material shall contain a uniform moisture content approaching optimum for the full depth of the excavation.

The contractor may, with the approval of the engineer, uniformly wet the area to be excavated prior to the removal of vegetation; or removing the vegetation from the area to be excavated and rip, along the contour of the ground, to an approximate depth of two feet on approximately four foot centers with provision for control of erosion in case of heavy rainfall. The engineer will determine when the vegetation shall be removed.

Watering shall be confined to the area to be excavated. The contractor shall conduct his watering operation to minimize waste. The engineer will estimate and deduct any undue waste of water from monies due or to become due the contractor.

Payment will not be allowed for water applied in excess of the quantity required to obtain optimum moisture.

The contractor shall provide adequate drilling equipment for checking the penetration of moisture for the full depth of the excavation area.

13.53 METHOD OF MEASUREMENT.

(A) Water used in accordance with article 13.52 (A) and (B) will be measured by the number of 1,000 gallon units as ordered, measured in the vehicle at the point of delivery on the road. Measuring may be done by a meter of an approved type, or manual count of the number of loads delivered or as counted by an approved type of a load counter affixed to the vehicle. All equipment for measuring, such as a meter or load counter, shall be furnished and installed, at the expense of the contractor.

(B) Water used in accordance with article 13.52 (C) shall be measured by an approved meter. The unit shall be the gallon, in thousands, to the

nearest 1,000 gallons. The contractor shall submit proof, as to the accuracy of the meter, which shall be reasonably up-to-date.

13.54 BASIS OF PAYMENT. The accepted quantities of this item shall be paid for at the contract unit price per 1,000 gallon unit of water, which price and payment shall be full compensation for the work.

When the contract does not stipulate an item for "Furnish and Maintain Water Plant," the performance of this item shall be considered incidental to and included in the other items of the contract. When stipulated in the contract, the item, "Furnish and Maintain Water Plant," shall be paid for at the contract lump sum price. No payment shall be made for the latter unless installation is authorized in writing.

Water used in surface cleaning preparatory to placing a subsequent course of bituminous surfacing or cover material will not be paid for separately but will be considered incidental to and included in payment for other contract items.

Water used in accordance with article 13.52 (B) will be paid for at the contract unit price per 1,000 gallon unit of water, which price and payment shall be full and complete compensation for the work, including the source of supply.

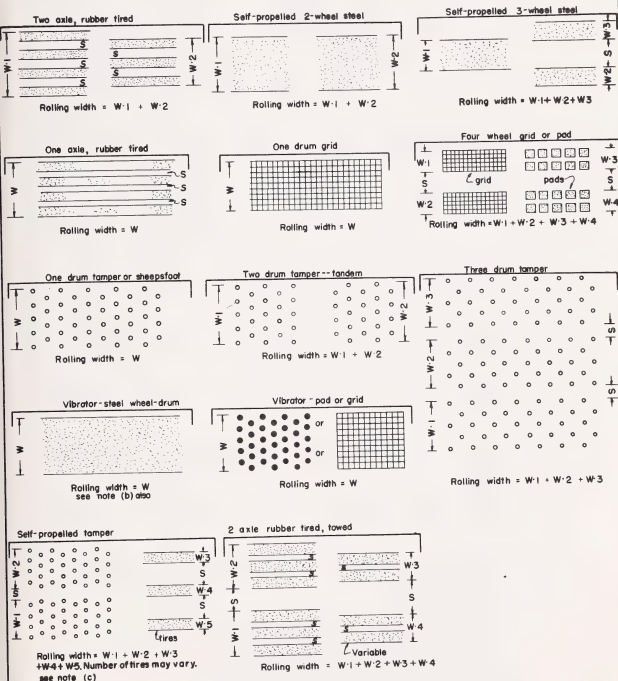
Water for dust control on haul roads or other conditions benefiting the traveling public shall be used only at locations and in amounts as directed.

No measurement or payment will be made for water used for dust control conditions, which in the opinion of the engineer, are not detrimental to the traveling public.

TABLE 1

Measurement Of Roadway Rolling

Examples Showing How To Measure Rolling Width. Sketches Show Tracks



- (a) When "S" is more than 12 inches it will not be included in rolling width. "S" is a single measurement, not a summation.
- (b) A 3 drum (steel wheel), with the middle wheel a vibrator, is being used. Measure each drum and add the 3 together.
- (c) One type of vibratory roller with steel drum in rear, rubber tires in front, would be measured like the sketch shows.
- (d) See std. dwg. no. 13-02 for methods of computation for measurement & payment.

MEASUREMENT OF
ROADWAY ROLLING

TABLE II

Total Measured	OPERATING WEIGHTS IN TONS (1)															
	0-2	2-4	4-6	6-8	8-10	10-12	12-15	15-19	19-24	24-30	30-37	37-45	45-54	54-64	64-75	75-87
20-27	0.314	0.529	0.743	0.958	1.172	1.382	1.600	1.814	2.029	2.243	2.458	2.671	2.886	3.100	3.314	3.529
27-34	0.292	0.507	0.721	0.936	1.150	1.364	1.578	1.792	2.007	2.221	2.436	2.649	2.864	3.078	3.292	3.507
34-41	0.271	0.486	0.700	0.915	1.129	1.343	1.557	1.771	1.986	2.200	2.415	2.628	2.843	3.057	3.271	3.486
41-48	0.249	0.464	0.678	0.893	1.107	1.321	1.535	1.749	1.964	2.178	2.393	2.606	2.821	3.035	3.249	3.464
48-55	0.228	0.443	0.657	0.872	1.086	1.300	1.514	1.728	1.943	2.158	2.372	2.585	2.800	3.014	3.228	3.443
55-60	0.206	0.421	0.635	0.850	1.064	1.278	1.492	1.706	1.921	2.136	2.350	2.563	2.778	2.992	3.206	3.421
60-65	0.185	0.400	0.614	0.829	1.043	1.257	1.471	1.685	1.900	2.115	2.329	2.542	2.757	2.971	3.185	3.400
65-70	0.164	0.379	0.593	0.808	1.022	1.236	1.450	1.664	1.879	2.094	2.308	2.521	2.736	2.950	3.164	3.379
70-75	0.142	0.357	0.571	0.786	1.000	1.214	1.428	1.642	1.857	2.072	2.286	2.500	2.714	2.928	3.142	3.357
75-80	0.121	0.336	0.550	0.765	0.979	1.193	1.407	1.621	1.836	2.051	2.265	2.478	2.693	2.907	3.121	3.336
80-85	0.100	0.314	0.528	0.743	0.957	1.171	1.385	1.600	1.814	2.029	2.243	2.456	2.671	2.885	3.100	3.314
85-90	0.078	0.293	0.507	0.722	0.936	1.150	1.364	1.578	1.793	2.008	2.222	2.435	2.650	2.864	3.078	3.293
90-95	0.056	0.271	0.485	0.700	0.914	1.128	1.342	1.556	1.771	1.986	2.200	2.413	2.628	2.842	3.056	3.271
95-100	0.035	0.250	0.464	0.679	0.893	1.107	1.321	1.535	1.750	1.965	2.179	2.392	2.607	2.821	3.035	3.250
100-105	0.014	0.229	0.443	0.658	0.872	1.086	1.300	1.514	1.729	1.944	2.158	2.371	2.586	2.800	3.014	3.229
105-110		0.207	0.421	0.636	0.850	1.064	1.278	1.492	1.707	1.922	2.136	2.349	2.564	2.778	2.992	3.207
110-115		0.186	0.400	0.615	0.829	1.043	1.257	1.471	1.686	1.901	2.115	2.328	2.543	2.757	2.971	3.186
115-120		0.164	0.378	0.593	0.807	1.021	1.235	1.449	1.664	1.879	2.093	2.306	2.521	2.735	2.949	3.164
120-125			0.357	0.572	0.786	1.000	1.214	1.428	1.643	1.858	2.072	2.285	2.500	2.714	2.928	3.143
125-130			0.335	0.550	0.764	0.978	1.192	1.406	1.621	1.836	2.050	2.263	2.478	2.692	2.906	3.121
130-135			0.314	0.529	0.743	0.957	1.171	1.385	1.600	1.815	2.029	2.243	2.457	2.671	2.885	3.100
135-140			0.293	0.508	0.722	0.936	1.150	1.364	1.579	1.794	2.008	2.221	2.436	2.650	2.864	3.079
140-145			0.271	0.486	0.700	0.914	1.128	1.342	1.557	1.772	1.986	2.200	2.414	2.628	2.842	3.057
145-150			0.250	0.465	0.679	0.893	1.107	1.321	1.536	1.751	1.965	2.178	2.393	2.607	2.821	3.036
150-155			0.228	0.443	0.657	0.871	1.085	1.298	1.514	1.729	1.943	2.156	2.371	2.585	2.800	3.014
155-160				0.422	0.636	0.850	1.064	1.278	1.493	1.708	1.922	2.135	2.350	2.564	2.778	2.993
160-165				0.400	0.614	0.828	1.042	1.256	1.471	1.686	1.900	2.113	2.328	2.542	2.756	2.971
165-170				0.379	0.593	0.807	1.021	1.235	1.450	1.665	1.879	2.092	2.307	2.521	2.735	2.950
170-175				0.358	0.572	0.786	1.000	1.214	1.429	1.644	1.858	2.071	2.286	2.500	2.714	2.929
175-180				0.336	0.550	0.764	0.978	1.192	1.407	1.622	1.836	2.049	2.264	2.478	2.692	2.907
180-185				0.315	0.529	0.743	0.957	1.171	1.386	1.601	1.815	2.028	2.243	2.457	2.671	2.886

185-190			0.293	0.507	0.721	0.935	1.149	1.364	1.579	1.793	2.006	2.221	2.435	2.649	2.864
190-195			0.272	0.486	0.700	0.914	1.128	1.343	1.558	1.772	1.985	2.200	2.414	2.628	2.843
195-200			0.251	0.465	0.679	0.893	1.107	1.322	1.537	1.751	1.964	2.179	2.393	2.607	2.822
200-205			0.229	0.443	0.657	0.871	1.085	1.300	1.515	1.729	1.942	2.157	2.371	2.585	2.800
205-210			0.208	0.422	0.636	0.850	1.064	1.289	1.494	1.708	1.921	2.136	2.350	2.564	2.779
210-215			0.187	0.401	0.615	0.829	1.043	1.268	1.473	1.687	1.900	2.115	2.329	2.543	2.758

1. Operating weight in tons. "10-12" means ten tons or more but less than twelve.
2. Rolling width means total width of track or tracks made by roller, measured in inches. See Standard Drawing No. 13-01. "48-55" means 48" or more, but less than 55", etc.
3. When the drive wheels or drums of a power unit are designed and constructed for rolling and compacting, then such wheels or drums will be included in rolling width.
4. When the roller is a vibrating type, the factor in Drawing 13-02 is to be multiplied by 2 to determine pay quantity. The weight to be used is the operating weight.
5. When the roller is a towed tamping roller, multiply the factor in Drawing 13-02 by 1.50 to determine pay quantity.
6. When more than one roller is pulled by only one power unit, measure all rollers and add together as a team combined into one roller.

7. The power unit is not to be included in any measurements when the rolling equipment is being towed.

8. For roller widths and roller weights not on the table, project at same rates within the table. All projections computed in field offices must be approved prior to use, by the Helena Office.

9. Illustrative computation of pay quantity:

- (a) Measure rolling width! Answer---157 inches
- (b) Determine operating weight. Answer 34.5 tons
- (c) The pay time for the roller in a pay period is 210 hours.
- (d) Look in Drawing 13-02 on the line including 157" (155-160), under the column including 34.5 tons (30-37), find unit value of 1.922
- (e) Multiply 1.922 by 210, getting 403.6 units.

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SECTION 16

CONTINGENT CONSTRUCTION AND OPERATIONS

SUBSECTION 16.00 EQUIPMENT USE

16.01 DESCRIPTION. "Equipment Use" shall consist of the furnishing, by the contractor, for use on the project and for performance of work specified or directed by the engineer, any of the units of equipment herein described, when indicated by the plans or stipulated in the contract.

16.02 EQUIPMENT.

(A) General Requirements. Any equipment furnished shall be in good mechanical condition and shall have sufficient motive power for successful continuous performance of the assigned work. Any equipment not capable of meeting these requirements will not be permitted on the work.

(B) Motor Grader. The motor grader shall be the self-propelled type, either tandem or all wheel drive, equipped with pneumatic tires. It shall be equipped with a moldboard at least twelve feet long with a suitable cutting edge, a scarifier with nine or more teeth having minimum dimensions of 3 in. by 1-in. by 16 ins., and power-operated controls. It shall be propelled by an engine having a manufacturer's rating of at least 100 horsepower.

(C) Dozer. The dozer may be of any standard type attached to a crawler-type tractor having at least 75 horsepower and power operated controls. The dozer shall be not less than 90 inches long. The dozer and tractor will be considered a single unit.

(D) Power Shovel. The power shovel shall be of the full-revolving crawler type, and shall have a bucket of the size recommended by the manufacturer for use with the shovel furnished. The size of the shovel will be indicated in the contract by specifying the capacity of the bucket.

(E) Dragline. The dragline shall be of the full-revolving type, equipped with a bucket of at least the size specified in the contract, this bucket shall in no case be larger than that for which the machine is designed.

The one cubic yard dragline shall have a boom at least 45 feet long and a working radius of at least 35 feet.

The 2½ cubic yard dragline shall have a boom at least 80 feet long and a working radius of at least 60 feet.

Any other size of dragline shall have the boom length and working radius specified in the plans or special provisions.

For swamp work, one set of mats shall be furnished for each dragline.

Each mat shall have a length of not less than twice the distance between the outside edges of the crawler treads. The combined width of all the mats shall equal at least twice the bearing length of the crawler treads.

(F) Scraper. The scraper may be self propelled or drawn by a tractor. The motive power shall be capable of operating the scraper efficiently. The manufacturer's rated struck capacity will be used when determining the scraper capacity. It shall be a minimum of 20 cu. yds. The capacity shall not be less than that stated in the contract.

(G) Tractor Loader. The tractor loader shall consist of a crawler type or rubber tired tractor, equipped with a power operated loader having a bucket with at least the struck capacity for standard weight material specified in the contract. It shall be capable of excavating to a depth of at least 2½ inches below the bottom of the treads (or tires) and loading the excavated material on the trucks used for hauling.

(H) Wheel Tractor. Wheel tractors shall be a farm or industrial type tractor equipped with pneumatic tires and capable of pulling the rollers or trailer type rotary tillers, described herein. The tractor shall be propelled by an engine having a manufacturer's rating of at least 32 horsepower.

(I) Truck. The truck shall have a minimum manufacturer's rated capacity of at least 1½ tons and shall have a volumetric capacity of not less than five cubic yards. It shall be equipped with a power-operated hoist and a metal dump box of the end dump type. The rear axle of the truck shall be equipped with dual wheels and tires not less than 8.25 inches in diameter (manufacturer's designated size).

(J) Rotary Tillers. Rotary tillers shall be a pulverizing and mixing unit consisting essentially of a power-driven rotor fitted with tines or teeth. The rotor unit may be mounted on either a pneumatic-tired tractor or a trailer. Each unit shall include two rotor assemblies fitted with tines made of spring steel. One rotor shall be designed for pulverizing and the other for mixing. Each rotor shall have a minimum effective width of six feet. Sufficient power shall be provided to drive the rotor at efficient speeds for both pulverizing and mixing operations. Suitable devices shall be provided to permit easy and positive adjusting to the depth of cut and the lowering and raising of the rotor to and from the cutting position.

(K) **Disc-harrows.** Discs shall be the tandem type with a minimum cutting width of five feet. Harrow sections or drags shall be a minimum of eight feet.

16.03 METHOD OF MEASUREMENT. Unless otherwise specified, equipment use will be measured by the hours, for the use of any unit specified, in the performance of actual assigned work. Time consumed in moving equipment from point to point on the project and for repairing and servicing will not be measured.

Measurement of the respective excavating loading unit hours will be adjusted up or down from the specified standard load capacity to reflect the actual efficient load performance capacity with the motive power necessary. Adjustment will be based on a direct capacity contract price ratio.

16.04 BASIS OF PAYMENT. Unless otherwise specified, equipment use will be paid for at the contract unit price per hour for the unit, when stipulated in the contract, which price and payment shall include furnishing the equipment on the project in completely operable condition, including operator, servicing, repairs and all incidentals necessary to complete the work.

SUBSECTION 16.10 ROAD LEVELER OPERATIONS.

16.11 DESCRIPTION. This item shall consist of using the road leveler equipment specified herein for the final shaping of those materials for which the road leveler is specified in the contract, directed by the engineer or otherwise required.

16.12 EQUIPMENT. Road leveler equipment, as referred to in this section shall consist of a leveler unit and a tractor-power unit of the type and specification given below, or a self-propelled unit performing equivalent functions.

(A) **Leveler Unit.** The leveler unit shall have a length of approximately 40 feet and a cutting blade width of not less than ten feet. The machine shall have pivot points, both in front and behind the center point of the machine, to permit turning on a minimum radius. It shall be mounted on pneumatic tires or approved crawler type treads.

The leveler shall be equipped with hydraulic power fittings so that the lifting and lowering of the cutting blade is controlled from the power-traction unit.

A machine of less than 40 feet in length may be used if operated off an approved string line with adequate electronic controls.

(B) Tractor Power Unit. The tractor-power unit for towing the leveler, unless it is adequately self-propelled, may be of the pneumatic tire or crawler track type and shall have adequate power for the operation of the leveler at a speed of four miles per hour. It shall be equipped with a two-way hydraulic system, with controls for operating the leveler cutting blade.

(C) Operation. The operating speed of the road leveler equipment shall be that which produces the most satisfactory results.

16.13 CONSTRUCTION METHODS. After the surface of the final course of materials, for which the use of road leveler equipment is specified or directed, has been finished as specified for the item, the contractor shall make one or more coverages of the entire surface with the road leveler to eliminate any transverse or longitudinal irregularities. If necessary to facilitate the planing operations, water shall be applied to the surface just prior to or during the use of the leveler.

The leveler shall be operated longitudinally starting from the crown of the roadway and working toward the shoulder on successive passes with some overlap on each cutting. At no time shall the leveler straddle the crown of the roadway; and care shall be exercised to maintain the crown established by the engineer.

16.14 METHOD OF MEASUREMENT Road leveler operation will be measured by the number of hours actually consumed in road leveler operations, as directed by the engineer, determined in conformity with Article 13.14 on the basis of an effective leveling width of ten feet.

16.15 BASIS OF PAYMENT. The number of hours of road leveler operation, determined as provided above, will be the contract unit price per hour for "Road Leveler Operation", which price and payment will be compensation for providing, maintaining, and operating the road leveler equipment, for all labor, including operator, equipment, tools, fuel, oil, lubricants and incidentals necessary to complete the item.

Road leveler operation will not be paid for directly, as described above, unless a bid item is made a part of the contract.

SUBSECTION 16.40 OBLITERATE ROADWAY.

16.41 DESCRIPTION. Obliterate Roadway, shall consist of the obliteration of such portions of abandoned roadways as shown on the plans or designated by the engineer in accordance with these specifications and as directed.

16.42 CONSTRUCTION METHODS. After the old road is no longer needed for traffic the old ditches shall be filled and the roadway graded, either to approximately restore the original contour of the ground or to produce a contour that will merge with the contour of the adjoining land. Where feasible, the old ditches may be filled by blading the existing surface material into them and covering it with suitable soil. Old structures, including guard rail, not included in other contract items for removing structures shall be broken down and buried or removed, as directed. All material with salvage value shall be carefully removed and neatly piled to avoid damage.

After the rough grading is completed the area of the old road surfacing shall be scarified or plowed to effectively mix the remaining surfacing material with earth. The entire area of the old roadway shall be harrowed, smoothed, seeded and left in generally smooth condition blending into the adjacent terrain, to the satisfaction of the engineer.

The species of seed and rate of application shall be determined by the engineer.

16.43 METHOD OF MEASUREMENT. The length of old roadway obliterated to be paid for will be (a) the number of miles and fractions thereof determined to the nearest one-hundredth or (b) the number of stations of roadway, measured along the centerline of the old roadway being obliterated as required and accepted, or measured as specified by Article 11.06, obliterated as required.

16.44 BASIS OF PAYMENT. When the contract contains an estimated quantity for "Obliterate Roadway," the number of miles, stations, square yards, or cubic yards, determined as provided above, will be paid for at the contract unit price for "Obliterate Roadway," which price and payment will be full compensation for the work, except:

(A) Material obtained from the old roadway and used in construction of the new roadway will be paid for under Section 11, or Section 12, as the case may be.

(B) When the contract does not contain an estimated quantity for "Obliterate Roadway," this item will not be paid for directly but shall be considered incidental to and included in payment for the other items of the contract.

NOTES

SECTION 17

ROADSIDE DEVELOPMENT

SUBSECTION 17.00 TOPSOILING

17.01 DESCRIPTION. Topsoiling shall consist of furnishing, excavating, hauling, depositing, spreading and preparing for seeding an approved topsoil material in accordance with this specification. The topsoil material described herein will generally be placed on interchange areas and rest areas to be seeded. Placement, preparation, finishing and similar work shall be performed in reasonable close conformity with the lines, grades and dimensions shown on the plans or as directed.

17.02 MATERIALS. Topsoil shall be furnished by the contractor. It shall be a fertile, friable soil of loamy character and shall be reasonably free of trash, rocks, hard lumps of soil, stumps or brush. Ordinary sod or soil containing grass roots shall be broken up before being placed. Broken up sod or soil shall be capable of passing a 2-inch sieve opening.

The contractor shall notify the State, promptly after contract award, of his intended source of topsoil. Topsoil work shall not begin until test results of the topsoil samples are known.

Topsoil shall meet the requirements of Article M-340.06.

The contractor shall make his own arrangements for obtaining topsoil. He shall pay all costs involved including royalties and other costs for developing the source and smoothing and leveling the source after removal.

17.03 CONSTRUCTION METHODS. Areas to be covered with Topsoil shall be completed to the lines, grades and elevations designated or shown on the plans. Topsoil shall not be placed until the areas to be covered have been properly prepared and all construction work in the area has been completed.

All slopes to be topsoiled shall have a rough surface. Smooth slopes shall be scarified to facilitate holding topsoil in place.

After the topsoil has been spread, all large clods, hard lumps, rocks, large roots, litter, or other foreign material shall be raked up, removed from the topsoiled areas and disposed of. The topsoil shall be brought to a friable condition to an average depth of four inches when finished to the

lines, grades and locations designated on the plans. Spreading shall be completed in such a manner that seeding or planting can proceed after completion of this item without additional soil preparation of any nature.

17.04 METHOD OF MEASUREMENT. Topsoil will be measured by the cubic yard of loose material level with the box in the hauling vehicle at the point of placement on the project. The contractor shall strike or level any load when directed.

When necessary to remove any material such as rock, hard dirt, clay, weeds, roots, or any other deleterious matter from the topsoil after placing, the amount of such material will be measured by the cubic yard, returned to the topsoil source and it will be deducted from the total amount of topsoil placed.

17.05 BASIS OF PAYMENT. Topsoil used in the completed and accepted work will be paid for at the contract unit price which price and payment will include furnishing, royalties unless otherwise stipulated, loading, hauling, placing, pulverizing, spreading, shaping, watering, smoothing, finishing and for all other charges; for maintenance of the completed surface until acceptance and for everything necessary to complete the work.

SUBSECTION 17.10 SEEDING AND FERTILIZING.

17.11 DESCRIPTION. Seeding and fertilizing shall consist of ground surface preparation, furnishing and application of fertilizer, furnishing and planting seed, cleanup and finishing.

17.12 MATERIALS.

(A) Grass Seed. All seed shall comply with and be labeled in accordance with Montana Seed Law. As listed in the Montana Seed Law, grass seed shall contain no "PROHIBITED" noxious weed seed. However, a variance from their "RESTRICTED" noxious weed seed listing will be permitted according to the following table:

Species	Number Allowed per pound
Curled dock (<i>Rumex crispus</i>)	45
Wild oats (<i>Avena fatua</i>)	45
Ox-eye daisy (<i>Chrysanthemum leucanthemum</i>)	90
Buckhorn plantain (<i>Plantago lanceolata</i>)	90

The number of seeds allowed per pound, for all other noxious weed seeds shown on the "restricted list," will be zero.

Seed shall have been grown in the North American continent above 41 degrees north latitude. All seed shall be a standard grade adapted to Montana conditions. Seed which has become wet, moldy or otherwise damaged will not be accepted.

Calculations of pure "live seed" may be made on the basis of either a germination test or a tetrazolium test in addition to the purity analysis. Seed shall be applied on a pure "live seed" basis. The quantity of pure "live seed" in a 100 lb. container shall be determined by the formula: 100 multiplied by germination percentage and this product multiplied by the purity percentage. (For example, if the seed is 85% pure and test 90% germination, then a 100 lb. container would contain 76.5 lbs. of pure "live seed").

Each species of seed shall be made available, in separate bags, for sampling and inspection.

The engineer shall be furnished a purity analysis and germination test of the seed proposed for use. The germination test shall have been made within a period of nine months before the seeding date

Sampling seed: The contractor shall notify the State, in writing, of his seed source and the approximate date that he expects to begin seeding. The notification shall be submitted in sufficient time to allow the State to obtain and test samples of seed before the contractor actually begins seeding. Seeding shall not begin until the test results of the seed samples are known.

(B) Legume Seed. Source, grade, purity, germination and "live seed definition" for legume seed shall be the same as for grass seed. When legumes are seeded, inoculants specified by the special provisions shall be used.

(C) Fertilizer. Fertilizer shall be a soluble commercial carrier of available plant food element or combination thereof. The fertilizer to be used on the project shall supply the quantities of available chemical elements stipulated in the special provisions or on the plans. The fertilizer shall be in uniform in composition and in good condition for application by suitable equipment. It shall be labeled with the manufacturer's guaranteed analysis as governed by applicable fertilizer laws. Any fertilizer which becomes contaminated or damaged, making it unsuitable for use, will not be accepted.

(D) Water. Water used for seeding shall be of irrigation quality, free of impurities that would be detrimental to plant growth.

17.13 CONSTRUCTION METHODS.

(A) General. Areas to be seeded shall be completed, in reasonable conformity, to specified line and grade prior to seeding and fertilizing.

It is necessary, in so far as it is practicable and feasible, as determined by the engineer, that the seedbed surface, at the time of application of seeds, be reasonably free of large lumps, clods, and impervious crusts of dirt; that there be no appreciable areas of loose soils which can feasibly be compacted; that the surface, to a depth of approximately two inches, not be so tightly compacted that seed cannot begin growth. The contractor shall treat such areas, as shall be directed by the engineer, to attain, as nearly as practicable, the condition described.

If good seeding can be attained with the vegetation standing, it shall then be mowed and left lay after seeding. Mowing shall be done, where terrain permits, with equipment using a cutting blade which rotates in a plane parallel to the ground. Whether the vegetation is live or dead, if it will prevent good seeding practice, it shall be removed. Vegetation that has matured and lost its leaves need not be mowed.

Slopes and areas finished in the winter and spring shall be permanently seeded before the end of the spring seeding period. Slopes and areas finished during the summer and early fall shall be permanently seeded during the fall seeding period unless otherwise specified.

Permanent seeding of the finished slopes during the specified spring and fall seeding periods will require frequent seeding operations and shall not be construed to mean that the required finishing, topsoiling, fertilizing, mulching, permanent erosion control placement and seeding can be done at the convenience of the Contractor. Any additional move-in required will not be paid for separately as the cost thereof shall be absorbed in the contract unit price for the various seeding, fertilizing, mulching and mobilization items.

(B) Conditioning Seedbed Surface. Equipment used in "Conditioning Seedbed Surface", shall conform to the provisions of Article 16.02 (J), (K) and (L). Any other equipment used in conditioning must prove satisfactory, in operation, to the engineer.

The quantity of "Conditioning Seedbed Surface" set forth in the contract is approximate only and may vary considerably on actual construction. It is included as an arbitrary quantity for providing a unit price for payment purposes. This quantity is not guaranteed to be used or required and the State reserves the right to increase, decrease or omit all or any part of the item and no compensation will be allowed by reason thereof. Cultivation, tillage, harrowing, disking, or similar operations may

be performed at any time, after the contract is awarded, with the engineer's approval.

(1) Areas that shall not receive conditioning are: Areas not designated for seeding; solid rock; slopes composed predominantly of gravel or rock or both; sandy soil; areas that are damp or soft at the time of seeding; areas where seed may penetrate and be retained by the soil providing seed growth will begin and continue to maturity; areas having a substantial and satisfactory cover of dead or live non-noxious vegetation which will not prevent good seeding practice.

(2) Areas that shall require conditioning are all areas not included in part 1 above and: areas containing dead or live vegetation which prevents good seeding practice; hard, slick or crusted areas or other areas upon which seed cannot adequately penetrate; areas upon which a drill cannot adequately penetrate; roadway inslopes and backslopes on a slope greater than 3:1 may require conditioning if the engineer so orders; areas which are to be seeded by hydro-blower unless part 1 above eliminates conditioning.

(3) Compacting of loose soils may be required by the engineer. Excessively tight or compacted soils shall be loosened to a minimum depth of two inches. The use of a disc, harrow, cultipacker, or similar equipment, will be permitted subject to the engineer's approval. Discing, harrowing or soil tilling shall be done at right angles to the natural flow of water on the slopes unless otherwise ordered by the engineer.

Compaction of the soil, when required, shall be performed by equipment capable of producing a uniform rough textured surface ready for seeding and mulching. Compacting equipment shall be operated parallel to the natural flow of water on the slopes unless otherwise directed. The soil surface, after compaction, shall be a minimum of one inch and a maximum of one and one-half inches below the top of all curbs, catch basins and other similar structures.

(C) Seed Distribution.

(1) **General.** Seed shall be applied to the conditioned seedbed no longer than 48 hours after the seedbed has been conditioned.

The seeding of inslopes, narrow medians or small areas which are impractical to seed by drill may be performed by using method C-3.

Seeding method C-4 shall be used when the seedbed surface is too wet or swampy to permit seeding by drill.

Seeding methods C-3 or C-4 shall not be used during adverse weather.

The applied seed, regardless of the method of application, shall not be covered by a soil thickness greater than one half inch in depth.

The basic rate of seed application will be described in the special provisions.

(2) Seeding by Drill. Seeding equipment used for applying grass seed must be designed, modified or equipped to regulate the application rate and planting depth of grass seed. If equipment for sowing seed is not equipped with press wheels, the seed shall be compacted with a cultipacker immediately after the ground has been drilled. Seed must be uniformly distributed in the drill hopper during the drilling operation. Equipment furnished with grass seeding and fertilizing attachments are preferable to separate operations. Acceptable drills are: custom seeders, furrow drills, disc drills or other drills approved by the engineer. All grass establishment equipment shall be operated normal to the slope drainage.

Planting depth shall be regulated by depth bands or coulter. The drill box shall be partitioned by dividers, no more than 24 inches apart, in order to provide for more even distribution on sloping areas. A drill shall be no wider than the width of the area over which it is to operate.

The rows of planted seed shall be a maximum of eight inches apart and shall be at right angles to the natural slopes.

(3) Broadcast Seeding. Seeding by hand or mechanical broadcasting will be permitted on areas inaccessible to drills or impractical to seed by other prescribed methods. Broadcast seeding requires the approval of the engineer.

(4) Hydraulic Seeding. When impractical to drill, hydraulic seeding equipment may be used. The seeding special provisions will indicate which slopes require seed coverage. Generally, seed mulch and fertilizer will be applied in separate and distinct operations except for the following:

(a) When using wood cellulose fiber or paper mulch, the contractor may combine either mulch with fertilizer to make one operation. However, mulch shall only be applied **after** the seed is in place. Under no circumstances shall seed be mixed with mulch. This is not intended to exclude using 100 to 150 pounds of wood cellulose fiber mulch per acre as a visual indicator when applying seed. The contractor may be required to use extension hoses to reach the extremities of slopes.

(b) When using vegetable mulch, the contractor may mix the seed with the fertilizer if his hydraulic seeding equipment is capable of uniformly mixing water, fertilizer and seed — **in that order** — and power blowing

or spraying the mixture uniformly over the seedbed. After blending , the slurry shall be applied to the seedbed with 60 minutes after the seed has been added to the water-fertilizer mixture. If the slurry cannot be applied within the specified 60 minutes it shall be fortified, at the contractor's expense, with the correct ratio of seed to the remaining slurry and a new 60 minutes time frame established for applying the fortified mixture. At no time shall seed and fertilizer remain in a slurry for more than 60 minutes.

(D) Application of Fertilizer. When seed is applied by Method (C-3), the fertilizer shall be applied separately from the seed and mixed into the soil by disc, harrow or hand methods. When Method (C-4) is used, seed, fertilizer and mulch shall be separate operations except as stated in Article 17.13 (C) (4).

(E) Finishing. When seeding is done by Method (C-2), and the surface is unduly loose, the seedbed shall be compacted by an agricultural roller, cultipacker or compactor not more than 24 hours after seeding. However, compacting will not be required where a roller-type grass seeder has been used.

(F) Seeding Dates.

1. Western Seeding Zone: The following counties shall comprise the Western Seeding Zone and seeding shall be permitted from October 15th through May 20th:

FLATHEAD	MINERAL
GRANITE	MISSOULA
LAKE	RAVALLI
LINCOLN	SANDERS

2. Eastern Seeding Zone: All counties not included in the Western Seeding Zone shall be included within this zone. Seeding shall be permitted from October 15th through April 30th.

(G) General. Existing structures and facilities shall be adequately protected and any damage done by the contractor shall be repaired or adjusted to the satisfaction of the engineer.

17.14 METHODS OF MEASUREMENT.

(A) Grass Seeding will be measured by the pound of live seed applied to the seedbed. Application of an amount more than 10% above that quantity authorized in writing will not be measured for payment.

(B) Fertilizing will be measured by the ton of 2,000 pounds, unless

another method is specified. Measurement will be made only of the minimum respective weights of available ingredients.

The quantity of fertilizer specified is the sum of the minimum pounds of available ingredients required. Each ingredient, from commercial fertilizers having a fixed ratio of ingredients, is acceptable in weights up to five pounds over the minimum required. The number of pounds of available ingredients to be applied are called for on the plans.

(C) Condition Seedbed Surface will be measured by the actual hours of equipment work on the seedbed surface, both preparation and finishing, or on a unit area basis of 1,000 square feet whichever is set forth in the contract.

(D) Water used in application of seed will not be measured for payment.

17.15 BASIS OF PAYMENT.

(A) Seeding will be paid for at the contract unit price, which price and payment shall be full compensation for furnishing all seed, hauling, planting, spreading, and for all other attendant operations necessary to complete the work.

(B) Fertilizing will be paid for at the contract unit price for fertilizer, which price and payment shall be full compensation for furnishing all materials and completing the work as specified.

(C) Conditioning Seedbed Surface will be paid for at the contract unit price per hour, or on a unit of area basis of 1,000 square feet, which price and payment shall include all costs involved in the use and operation of such equipment for both preparation and finishing.

SUBSECTION 17.20 MULCHING.

17.21 DESCRIPTION "Mulching" shall consist of covering and processing specified seeded areas with a mulch of the stipulated materials.

17.22 MATERIALS.

(A) General. Mulching materials used on the project shall be those stipulated in the Special Provisions or stipulated as items in the contract and described hereafter:

(1) On projects which require a specific mulch, that type will be

shown as the contract item, i.e. "Vegetative Mulch" or "Wood Cellulose Fiber Mulch," and the type specified will be the only type accepted for use.

(2) On projects which can be mulched equally well by any one of several types, the contract item will be "Mulch" and the special provisions will specify the types acceptable. The contractor will have the option of selecting which one of the specified types he will use. However, once selected, only one type of mulch will be used throughout the project.

(B) Vegetative Mulch. This type of mulch material shall be composed of wheat straw, rye straw, barley straw or grass hay, in that order of preference.

Chopped or ground material is not acceptable. The mulch material is not acceptable if it is musty, moldy, or rotted or if it contains seed bearing stalks of noxious weeds or grasses. It shall be free of stones, dirt, roots, stumps or other foreign material.

(C) Bituminous Mulch. This type of mulch shall be SS-1 Emulsified Asphalt. Its chemical composition must be such that it will be non-toxic to plant life. Application temperature shall not be less than 50 degrees F.

(D) Fabricated Mulch. Fabricated mulch acceptable to the engineer shall be made of jute, burlap, or kraft paper string. Samples shall be submitted to the laboratory, if necessary, before use. It shall be a material made and commonly used for the purpose of preventing erosion of soil surfaces.

(E) Fabricated Netting. Fabricated netting shall be made up of jute, burlap, kraft paper string or similar products. It may be made up on the project or prefabricated. The material must be approved prior to use and, if required, samples submitted to the laboratory. It shall be installed as directed by the engineer.

(F) Wood Cellulose Fiber Mulch. Wood cellulose fiber mulch shall consist of specially prepared wood cellulose fibers, and shall be processed in such a manner that it will not contain any growth or germination inhibiting factors. The fiber shall be dyed an appropriate color to facilitate visual metering during application. The mulch shall be of such a consistency that after being combined in a slurry tank with water, fertilizer and other approved additives, the fibers in the material will be uniformly suspended to form a homogeneous slurry. During application the material shall produce a mat-like net covering the grass seed. Wood cellulose fiber shall be supplied in packages. Each package shall be marked by the manufacturer to show the air-dry weight content. All mulch material must be acceptable to the Engineer. If requested, by the engineer, the con-

tractor shall submit a signed statement certifying that the material furnished has been laboratory and field tested and that it meets requirements and intents specified.

(G) Paper Mulch. Paper mulch shall be composed of waste paper selected and processed in such a manner that it contains no growth inhibiting factors. After recycling, the processed products shall be 100% free of any paper clips or other metal objects, plastic bits and pieces or other foreign matter classified as non-biodegradable. The mulch shall be of such a consistency that after being combined in a slurry tank with water, fertilizer and other approved additives, the paper mulch will remain in uniform suspension under agitation. When applied by hydraulic means to ground surfaces the paper mulch must form a strong moisture holding mat capable of holding seed in contact with the soil without smothering the seed. The paper mulch may be dyed an appropriate color to facilitate placement or, a non-toxic dye may be added to the water. Paper mulch shall be applied at the rates shown on the Plans or as stated in the Special Provisions. Paper mulch shall be supplied in packages. Each package shall be marked by the manufacturer to show the air-dry weight content. The percentage of moisture shall not exceed 15 percent.

17.23 CONSTRUCTION METHODS.

(A) General. Mulch as described in 17.23 (B), (C), (D) or (E), when required, must be applied to seeded areas not more than 24 hours after seeding regardless of the type used. It shall not be applied in the presence of free surface water, but may be applied upon damp ground.

Mulch shall not be applied to areas having a substantial vegetative growth, such as grasses, weeds and grains. Mulching shall not be done during adverse weather conditions or when wind prevents uniform distribution. Application, if after seeding, shall be in a manner to not seriously disturb the seedbed surface. All roadway structures and facilities shall be protected and kept undamaged from application of bituminous material and other operations. Any such material deposited on such structures or facilities shall be removed, at the expense of the contractor, to the satisfaction of the engineer.

(B) Application of Vegetative Mulch. Vegetative mulch shall be applied after seeding and fertilizing is completed unless otherwise directed. The mulch shall be applied in a uniform manner by a mulch spreader, at the rate specified in the Special Provisions or Plans. The

vegetative material shall be fed into the mechanical mulch spreader at an even, uniform rate.

When asphalt is used as a binder for vegetative mulch, it shall be applied at the rate specified in the Special Provisions or Plans. It shall be evenly distributed over the vegetative material as it emerges from the blower discharge. Uneven distribution, caused by inadequately powered or improperly adjusted equipment, poor workmanship, erratic material feed or discharge, or similar causes within the contractor's control, shall be corrected. The quantity of asphalt specified is subject to increase or decrease, as directed.

When specified in the Special Provisions or Plans, vegetative mulch shall be anchored into the seedbed by tucking. If temporary erosion controls are needed the contractor may elect straw tucking to be followed by permanent seeding at the proper time. Tucking shall be done only on those slopes flat enough to accommodate the machinery safely; this would normally be slopes no steeper than 3:1. All mulch tilling shall be done perpendicular to the flowline of the slope.

Prior to tucking, slopes shall be shaped but not smooth graded and topsoiled if specified. Straw or native hay shall be uniformly spread at the rate specified in the plans or Special Provisions and tucked into the soil with a mulch tiller. Straw or hay shall have a minimum length of eight inches and shall be pliable. If straw breaks during tucking it shall be sprinkled, **not** soaked, to facilitate placement.

Mulch tillers shall have round, notched blades of these approximate dimensions, $\frac{1}{4}$ inch thick by 18 inches in diameter and spaced eight inches apart. The tiller shall have sufficient weight to force the vegetative mulch a minimum of three inches into the soil and shall be equipped with disc scrapers.

The drill used to seed through straw stubble shall be a disc type furrow opener capable of seeding through the straw mulch without destroying its erosion prevention qualities.

(C) Application of Bituminous Mulch. When asphalt emulsion is the only mulch material stipulated in the contract or plans, it shall be applied at a rate of approximately two-tenths gallons per square yard (1000 gallons per acre) by blowing or other means that will not disturb the seedbed surface. It shall not be applied prior to seeding. It shall be applied at such a velocity that will not cause surface erosion. It must not be applied in such quantity as to completely blanket the ground surface. It shall be applied only to slopes steeper than 3:1, excepting that, in cut sections, the inslope shall be included if the backslope is so treated. Inadvertent

spillage onto flatter slopes between the blowing equipment and the designated slope shall be held to a minimum.

(D) Application of Fabricated Mulch and Fabricated Netting. Fabricated mulch shall be laid on the areas specified on the plans or directed by the engineer and securely fastened to the ground by wire staples, wooden pegs or other satisfactory devices. Application shall be after seeding.

(E) Application of Wood Cellulose Fiber Mulch. Wood cellulose fiber mulch and fertilizer or paper mulch and fertilizer may be applied in one operation by means of hydraulic equipment which utilizes water as the carrying agent. A continuous agitator action that keeps fertilizer and mulching material in uniform suspension, must be maintained throughout the distribution cycle. The pump pressure shall be capable of maintaining a continuous non-fluctuating stream of slurry. The slurry distribution lines shall be large enough to prevent stoppage. The discharge line shall be equipped with a set of hydraulic spray nozzles which will provide an even distribution of the solution to the seedbed. Mulching shall not be done in the presence of free surface water resulting from rains, melting snow or other causes.

The contractor shall start at the top of the slope and work downward. If necessary, he may be required to use extension hoses to reach the extremities of slopes.

(F) Finishing. Prior to final acceptance of the project, the contractor shall immediately remulch any area from which the original mulch may have been washed or blown. If the original seedbed and seeding is damaged due to the displacement of the mulching material, the seedbed shall be repaired and reseeded before remulching. The operations described in this paragraph shall be at the contractor's expense if the damage is due to his negligence.

17.24 METHODS OF MEASUREMENT.

(A) Paper mulch, vegetative mulch and wood cellulose fiber mulch. The quantity of mulch for which payment will be made will be the number of acres mulched in accordance with the plans, specifications and as directed by the engineer.

(B) Fabricated Mulch or Netting. Fabricated mulch or netting will be measured by the square yard accepted in place. The final quantity may be considerably more or less than the quantity in the contract.

17.25 BASIS OF PAYMENT

(A) Paper Mulch, Vegetative Mulch and Wood Cellulose Fiber Mulch. The mulch will be paid for at the contract unit price per acre complete in place measured as specified to the nearest one hundredth acre. Payment shall include the cost of furnishing and placing the mulch, binder, water and other items necessary and incidental to complete the placing of the mulch as specified. Seed to be placed with the mulch will be paid for as a separate item in conformity with Article 17.15, (A).

(B) Fabricated Mulch or Netting. Fabricated mulch or netting will be paid for at the contract unit price, which price and payment shall be full compensation for furnishing and applying to the seedbed surface all materials in conformance with the specifications and plans.

SUBSECTION 17.30 SODDING**17.31 DESCRIPTION.**

Sodding shall consist of preparing the ground surface, furnishing, transporting and placing live sod and other materials required in sodding operations on areas specified on the plans or designated by the engineer, conforming to these specifications.

17.32 MATERIALS.

Sod shall consist of a living vigorous growth, predominantly of the grass type and thickness specified. It shall have a dense root system, be native to the general locality of the project and shall be reasonably free from noxious weeds and grasses and from other foreign substances detrimental to the development and future maintenance of the sod.

At the time the sod is cut, the grass on the sod shall have a length of approximately two inches. If longer than three inches, the grass shall be cut to approximately two inches in length. The sod shall be raked free of debris.

If the sod, which is to be cut, is in a dry condition so that it cannot be cut, rolled, loaded, and hauled without undue crumbling or breaking the contractor shall, at least twelve hours before cutting the sod, apply water in sufficient quantities to provide a well-moistened condition of the sod to the depth to which it is to be cut.

Water used on sod shall be from a municipal, domestic, or other source known to be suitable for irrigation.

17.33 SEASON.

Sodding operations shall be done during the normal season for planting

or at such time as indicated on the plans, special provisions, or authorized in writing by the engineer.

The sources of sod shall be furnished by the contractor. The contractor shall notify the engineer of the source not less than three days before cutting of sod begins. The sod will be approved by the engineer in its original position before cutting and delivery to the project.

17.34 CONSTRUCTION REQUIREMENTS.

The surfaces to be sodded shall have been previously constructed to the required cross section, grade and contour, and shall be smooth and uniform and free from stones, roots or other undesirable foreign material. These surfaces shall be undercut to sufficient depth below adjacent areas that, when sodded, the top of newly-laid sod will be flush with any adjacent seeded or turfed areas and one inch below top of walks and curbs.

Immediately prior to placing the sod, the soil on the areas to be sodded shall be disced, harrowed or otherwise loosened and brought to a reasonably fine granular texture, to a depth of not less than two inches. All clods, lumps, weeds, or other unsatisfactory materials shall be removed to the satisfaction of the engineer.

All sod shall be machine cut into rectangular sections. The sections shall be of uniform width of not less than ten inches nor more than 18 inches. The sections may vary in length but nine feet shall be the maximum length.

The sod shall be cut to a depth of one inch or more as necessary, depending on the nature of the sod or soil. Practically all of the dense root system of the grasses shall be retained, but be exposed in the bottom side of sod strips, so that the sod can be handled without undue tearing or breaking.

Sod must be loaded, unloaded and placed by hand. The throwing of sod or use of pitchforks is not permitted. Dumping from vehicles will not be permitted.

Sod must be carefully placed and fitted as closely as possible with the joints staggered between horizontal rows.

The sod on slopes shall be laid by hand in horizontal strips, beginning at the bottom of the slope and working upwards. In waterways, the strips shall be laid parallel to the flow. The sod strips shall be staggered and shall fit snugly and evenly with those already in place. Any gaps or openings between the strips or sections shall be filled with pieces of sod cut to the proper size and shape.

On slopes, the bottom edges of sodded areas shall extend at least two inches into the ground or ditch bottom. All other edges of sodded areas

shall be turned into the ground and covered with a layer of topsoil, which shall be compacted and smoothed so as to blend the sod with the adjacent finished grades.

The sod shall be firmly compacted by rolling with an approved roller immediately after it is placed. After rolling, the sod shall present a smooth even surface, free from bumps and depressions. On slopes steeper than 3:1 the sod shall be fastened with appropriate devices capable of holding the sod firmly in place. The fasteners shall be spaced a maximum of two feet apart in any direction and shall be driven flush with the surface of the sod.

Sod shall be laid within 36 hours after cutting and shall be properly protected until placed. After the sod has been laid, acceptable to the engineer, it shall be thoroughly watered to provide a moist condition throughout the thickness of the sod and well into the underlying soil bed.

After the water has soaked in, the sod shall be rolled to insure good contact with the topsoil. The contractor shall keep the newly sodded lawn area well watered until the sod is firmly rooted. All sodded areas shall be fertilized, a minimum of two weeks after sodding has been completed, with inorganic fertilizer having minimum active ingredients of 35 lbs. N and 40 lbs. P_2O_5 per acre.

During the required watering period the contractor shall maintain the new sod until it is well rooted and shall replace any dead, dying or damaged sod as directed.

17.35 METHOD OF MEASUREMENT.

Sodding will be measured by the square yard (surface measurement), complete in place and accepted.

Necessary resodding of areas damaged from causes beyond the control of the contractor, will be measured and added to the original quantity used.

Water used in watering and pre-watering operations will not be measured for payment but will be considered absorbed in the other contract items.

17.36 BASIS OF PAYMENT

Sodding, measured as provided above, will be paid for at the contract unit price per square yard for "Sodding" which price and payment shall be full compensation for preparing the earth bed, furnishing, hauling, placing, anchoring, watering, rolling and/or tamping, and main-

taining the sod; and for all labor, equipment, tools and incidentals to satisfactorily complete the work.

SUBSECTION 17.40 SOIL RETENTION BLANKETS

17.41 MATERIALS

1. **Blankets.** Soil retention blankets shall be made of an approved uniform web of interlocking shredded wood fibers, with a backing of fabric net on one side only. The fabric net shall have a maximum mesh size of 1½ inches by 3 inches.

The blanket shall be produced to form a tightly compressed roll a minimum of 35 inches in width and approximately 150 feet in length. The fabric net shall be on the outside of the blanket.

Roll weight, when manufactured, shall be 40 pounds, plus or minus ten percent. Weight of each roll, width, length and the time of manufacture shall be written or stenciled on the roll wrapper or attached tag.

2. **Staples.** U-shaped staples, to hold blankets in place, shall be made from 11-gauge or heavier steel wire, they shall be approximately 2 inches wide at the throat and approximately 8 inches long after bending.

17.42 CONSTRUCTION METHODS.

1. The area to be covered shall be properly prepared, fertilized, and seeded before the blankets are placed. When the blanket is unrolled, the netting shall be on top and fibers, as far as practicable, shall be in contact with the soil over the entire area. The blanket shall be stapled at ends and corners and at approximately 5 foot intervals along the sides.

2. In ditches, blankets shall be unrolled in direction of the flow of water and lapped 4 inches over the adjoining roll. The ends and edges shall be buried uniformly to prevent undercutting by water or wind.

On slopes blankets may be unrolled horizontally or vertically to the slope, then lapped 4 inches over the adjoining blanket and stapled as provided in Article 17.41 (2). Blankets shall be lapped in the direction of flow in all cases.

17.43 METHOD OF MEASUREMENT.

Measurement shall be by the square yard of soil retention blanket in place.

17.44 BASIS OF PAYMENT.

The installation of Soil Retention Blankets shall be paid for at the contract unit price per square yard, which price shall be full compensation for all material and work necessary to complete the item.

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SECTION 18

LIME TREATED ROADBED

18.01 DESCRIPTION. This work shall consist of constructing one or more courses of a mixture of soil, hydrated lime and water, in accordance with these specifications, in reasonably close conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the engineer.

18.02 MATERIALS.

(A) Hydrated Lime. Hydrated lime shall meet the requirements of section M-340.03.

18.03 CONSTRUCTION REQUIREMENTS.

(A) Preparation of Roadbed. The surface of the roadbed shall be finished to the established lines, grades and cross section. Earth ramps at grade control points, namely, existing pavements, bridges, and the like, shall be removed to a depth to provide the required thickness of pavement structure. Excess excavated material shall be disposed of as directed.

Sufficient drains shall be cut through excavated material on the shoulders to drain the roadbed completely at all times. Drains shall be cut through windrowed base materials at sufficient intervals to prevent ponding of water and the windrowed material shall be moved, when necessary, to permit the roadbed to dry.

(B) Preparation of Materials. The prepared roadbed shall be scarified to the depth and width required for the lime treatment. The depth of scarification shall be carefully controlled and finishing operations conducted in a manner to provide that the surface of the roadbed below the scarified material shall remain undisturbed and shall conform to the established cross section. Prior to beginning stabilization work, all existing material and stones retained on a four inch sieve shall be removed. Some fill slopes may require temporary erosion control measures.

(C) Application of Hydrated Lime. The rate of application of lime shall be specified or as directed. Lime may be applied to the pulverized material as a slurry or dry.

Spreading equipment shall uniformly distribute the lime without

excessive loss. No equipment except water trucks and equipment used for spreading and mixing will be permitted to pass over the spread lime until it is mixed. Procedures which result in excessive loss or displacement of the lime shall be immediately discontinued.

(D) Addition of Water. Water may be added to the mixture of lime and roadbed material by means of pressure water distributors or by means of a traveling plant. Water shall be added during mixing operations to provide a moisture content in the range from the optimum moisture content to plus five per cent.

(E). Mixing. The lime and water shall be thoroughly mixed throughout the scarified material. The mixture shall then be placed in a windrow or spread over the roadbed and the surface sealed with a steel wheel or pneumatic roller to retard the loss of moisture, and aged for a period of not more than 72 hours nor less than 48 hours.

The aging period will be determined by the Engineer, based on temperature, weather conditions and construction procedure.

After thorough mixing has been accomplished additional water may be required to bring the mixture to the optimum moisture content plus or minus two per cent.

When traveling plants are used additional mixing with blades, tillers, discs, harrows or repeated passes of the plant may be required.

(F) Compaction and Finishing. After the aging period, the material shall be continuously mixed until a homogeneous friable mixture containing no clods of soil larger than 1½ inches is obtained. The mixture shall then be laid and compacted to a density of not less than 95 per cent of the maximum density determined in accordance with Montana Test Method M.T. 210. Field density determinations will be made in accordance with Montana Test Method M.T. 212 or other approved method. Light sprinkling may be required during laying operations to maintain the specified moisture content. Compaction shall be accompanied by sufficient blading to eliminate all irregularities.

The surface shall be lightly scarified during finishing operations and bladed to eliminate any imprints left by the equipment. Final rolling of the completed surface shall be accomplished with a pneumatic tire roller.

(G) Protection and Curing. Vehicles or equipment, other than sprinkling equipment, will not be permitted on the treated roadbed for a period of seven days after completion of the compaction and finishing of the treated roadbed unless otherwise directed. During the curing period the treated roadbed shall be lightly sprinkled with water, at frequent inter-

vals to prevent drying. Sealing with a light application of asphalt may be required.

Any damage to the treated roadbed by the contractor, shall be repaired at no cost to the Department. A minimum of one course of base material shall be in place before hauling operations are permitted over the treated roadbed. Depositing and spreading of base course material shall commence at the point of access and progress, without breaks, towards each end of the project.

18.04 Method of Measurement. Hydrated lime will be measured by the ton in conformity with Article 09.01. If sacked hydrated lime is used, the net weight as packed by the manufacturer will be used for measurement.

Water will not be paid for directly but will be considered incidental to and absorbed in payment for the other items of the contract.

Processing will be measured by the station or by the mile as indicated on the plans and shall include the preparation of the roadbed, the scarifying, pulverizing, drying of the material, the mixing of the various materials, the compaction of the mixture, finishing, and the protection, curing and maintenance of the completed roadbed.

18.05 BASIS OF PAYMENT. The accepted quantities of Lime Treated Subgrade will be paid for at the contract unit price per ton for hydrated lime and per station or mile for processing lime treated roadbed complete in place.

Payment will be made under:

Pay Item	Pay Unit
Hydrated Lime	Ton
Processing	Station or Mile

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SECTION 19

ROADBED MODIFICATION AND SURFACE PREPARATION

SUBSECTION 19.10 ROADBED MODIFICATION

19.11 DESCRIPTION. This work shall consist of scarifying the roadbed and the incorporation of aggregate and additives, if required into the scarified roadbed, or the addition and mixing of aggregate with materials obtained from the ditches and shoulder slopes, and the compaction of the mixture in reasonably close conformity to the depth shown on the plans; also the realigning of the shoulders and the cleaning and reshaping of the ditches if specified.

19.12 MATERIALS. Aggregates and additives, if required, for sub-grade modification, shall meet the requirements set forth in the plans or special provisions.

19.13 CONSTRUCTION REQUIREMENTS.

(A) Processing. If required by the plans, the shoulder slopes and ditches shall be bladed sufficiently to form an approximately uniform shoulder line neat in appearance. The material so obtained and the surfacing material existing on the road surface shall be spread uniformly over the roadbed. All weeds, sod, grass, roots, or other objectionable material obtained from the shoulder slopes and ditches shall be removed from the surface. If necessary to provide the required depth of subgrade modification, the roadbed shall be scarified to the necessary depth or additional material hauled in from designated locations. All material shall be thoroughly mixed and pulverized until not more than five per cent of the material exclusive of gravel or stone is retained on a two inch sieve. The material so mixed shall be placed in a uniform windrow.

The quantity of aggregate for subgrade modifications, as designated on the plans, shall be placed, windrowed, and brought to a uniform section. The windrowed materials shall be blended together until all materials are uniformly distributed throughout the combined windrow.

If required, additives shall be uniformly distributed and thoroughly mixed with the windrow.

Sufficient water shall be added during the mixing operation to provide the optimum moisture content plus or minus two per centage points unless otherwise directed.

The material shall then be spread uniformly to the required cross section and compacted in accordance with Article 11.05.

(B) Finishing and Curing. If a base or surface course is included in the contract, the surface of the completed roadbed shall be satisfactorily maintained until the base or surface course has been placed. If required, additional water shall be applied to prevent checking or raveling.

19.14 METHOD OF MEASUREMENT. Aggregate for subgrade modification will be measured by the cubic yard or ton in accordance with Article 09.01. All moisture in the aggregate, in excess of five per cent, shall be deducted when measured on the tonnage basis in accordance with Article 20.07.

Due to possible variations in the specific gravity of the aggregates, the tonnage used may vary from the contract quantities and no adjustment in contract unit price will be made because of such variation.

Water will be measured by the M-Gals. by means of calibrated tanks or distributors or by means of accurate water meters. Only that water which is used in mixing materials or applied as ordered by the engineer to keep the surface moist will be measured for payment. Additives, if required, will be measured as set forth in the plans or special provisions.

Processing for subgrade modification will be measured by the station or by the mile as indicated on the plans or special provisions.

It shall include all finishing of ditches and shoulders, if called for on the plans or special provisions; the scarifying and pulverizing of the existing surface; the placing and mixing of materials on the road; the compacting of the materials; the finishing of the surface; and the maintenance of the completed surface if applicable.

19.15 BASIS OF PAYMENT. The accepted quantities of subgrade modification will be paid for at the contract unit price per ton or cubic yard for aggregate for subgrade modification, per M-Gals. for water and per station or per mile for processing. Additives, if required, will be paid for as set forth in the plans or special provisions.

19.16 EXISTING SURFACE REMOVAL shall consist of the removing and disposal of the existing surface from the areas and to the depth required by the specifications and plans.

This work shall be accomplished in accordance with one of the methods herein described and as required by the plans for the particular type of new surfacing or by the method stipulated in the contract.

SUBSECTION 19.20 EXISTING SURFACE PREPARATION

19.21 DESCRIPTION. Existing Surface Preparation shall consist of reshaping, to the typical section, and truing the grade line of a previously completed earth subgrade section or gravel or bituminous surfaced road-bed, in preparation for the immediate construction of new surfacing as required by the specifications and plans.

19.22 CONSTRUCTION METHODS.

(A) Subgrade. All soft and unstable areas in the subgrade shall be excavated, the undesirable material removed from the roadway and the excavations backfilled with material satisfactory to the engineer. Holes and depressions which cannot be brought to true line and grade by blading shall be filled with suitable material, as directed. The entire subgrade surface shall be bladed to true line and grade, in conformance with the typical section and the requirements of Article 11.05. Roadway ditches shall be bladed clean and maintained for effective drainage. Shoulder lines shall be trued and roadway slopes shall be shaped and sloped to a point below the shoulder, consistent with the toe of the inslope elevation, to present a general uniform appearance of the work as required by the plans. It shall be maintained by the contractor, in the reconstructed condition, until the surfacing is placed.

All materials required to place the subgrade in acceptable cross-section and all rolling and watering required to secure adequate compaction will be measured for payment.

(B) Aggregate Surfaces. Methods of work performance and general requirements for aggregate surfacing preparation are essentially identical with those specified in Article 19.22 (A). When the aggregate surface is to be applied with any type of bituminous surface, the surface shall be prepared in accordance with the requirements thereof. Rocks or other similar objects protruding through the surface shall be removed and satisfactory repairs effected.

(C) Bituminous Surface. If the surface on which surfacing materials is to be placed is an existing bituminous surface, such surface shall be removed or left in place as stipulated in the contract or shown on the

plans. If removal is indicated, the existing surface shall be scarified, broken up and disposed of as directed.

If the bituminous surface is to be left in place, the surface shall be prepared as follows: Where the existing bituminous surface or bituminous patches show an excess of bituminous material, and where bituminous surfacing material has been placed over major settlements in the subgrade, the bituminous surfacing material shall be removed or reworked and satisfactorily stabilized as directed. Where the existing bituminous surface is corrugated, the unsuitable material shall be removed and the subgrade stabilized. The surface material shall be reworked and relaid, or replaced as directed.

Immediately prior to placing bituminous leveling material course or courses, the existing surface shall be thoroughly cleaned of dirt and loose extraneous material by means of power brooms, hand brooming, water washing or other methods necessary to accomplish satisfactory results. If stipulated in the proposal, or directed by the engineer, a prime or tack coat of bituminous material shall be applied to the cleaned surface in the amounts and over the areas as directed.

When stipulated in the contract or directed by the engineer, dips, depressions, sags, excessive or nonexistent crown or other surface irregularities shall be corrected by levelling with a specified pre-mixed bituminous material. The bituminous material shall be spread and compacted. A compacted layer shall not exceed two inches in depth and the total thickness of compacted layers shall not exceed six inches in depth. Surface irregularities exceeding six inches in depth shall be corrected with a specified non-bituminous aggregate material prior to levelling with a bituminous mixture.

Plant mixed bituminous material which is spread for leveling will be paid for at the contract unit price for plant mix bituminous material. No additional allowance will be made for spreading, leveling or rolling.

19.23 METHODS OF MEASUREMENT. Existing Surface Preparation will be paid for at the contract unit, or units, price or prices or other items required which prices and payment will constitute full compensation for the work. Unless otherwise provided, existing surface preparation will not be paid for directly but will be considered incidental and necessary to the performance of payment for the other items of the contract.

All materials, aggregates, surfacing course aggregate, bituminous material, bituminous mixed surfacing spread as the levelling material, watering and rolling, except rolling on plant mix bituminous surfacing,

used in the completed and accepted work for corrective purposes in "existing surface preparation" will be measured by the unit indicated in the contract, pertinent to the class of work performed.

19.24 BASIS OF PAYMENT. Existing Surface Preparation will be paid for at the contract unit or units, price or prices or other items required, which prices and payment will constitute full compensation for the work. Unless otherwise provided, existing surface preparation will not be paid for directly but will be considered incidental and necessary to the performance of payment for the other items of the contract.

All materials, aggregates, surfacing course aggregate, bituminous material or bituminous mixed surfacing spread as the levelling material, watering and rolling, except rolling on plant mix bituminous surfacing, will be paid for at the contract unit price, which price and payment shall be full compensation for the work.

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SECTION 20

AGGREGATE SURFACING

20.01 DESCRIPTION. This specification determines the general requirements of the various types of aggregate surfacing materials, kinds of equipment, production methods, construction methods, and other provisions concerning all aggregate surfacing.

The specific type and grading of aggregate surfacing shall be indicated on the plans or in the contract, the types and gradings are described in subsequent sections of these specifications.

20.02 MATERIALS.

(A) Aggregates. Aggregates shall meet the requirements of section M-100. They shall be obtained from acceptable sources which may be indicated on the plans or described in the contract or from sources selected by the contractor and approved by the engineer.

The portion of the material retained on a No. 4 sieve will be called coarse aggregate and that passing a No. 4 sieve will be called fine aggregate.

As determined by Montana Test Method M.T.—202, the material shall, for the maximum size or grade specified in the contract, including any binder or filler which may have been added at the plant or on the roadway, meet the requirements of that grade in the table of gradations for the type concerned.

Preliminary acceptance of all aggregate proposed for use in any type of surfacing may be made at the point of production, based only on those tests that can be performed at that point. All samples may be taken at the point of production but when the testing facilities at that point are not capable of making all necessary tests, then the samples will be sent to a central or other adequate laboratory and final and complete acceptance will be based on review of the resultant test reports. Acceptance of aggregates produced for mixing or blending with other materials will be based upon the same conditions set forth in the two preceding sentences. The above provisions apply only to those materials produced for immediate incorporation into the roadway and do not apply to materials which will be put into a temporary stockpile for incorporation into the roadway at a later date by the contractor producing the material. Acceptance of materials taken from a stockpile for incorporation in the roadway will be based on samples and tests made at the time the material is removed from said

stockpile. Attention is directed to Section 6 which pertains to sources of materials.

(B) Binder. When such material, in addition to that naturally present in any type of aggregate surfacing material, is required for satisfactory bonding and gradation prerequisites, it shall consist of fine natural soil particles or crusher dust, free from grass, roots, weeds, humus, or other undesirable matter. Its binding properties shall be such that, when added and blended with any type of aggregate surfacing material, it shall provide the final product with the physical structure and other properties required by the particular specifications.

Sources of binder will be indicated in the contract, be shown on the plans or be designated by the engineer. When the source is "Department Optioned" the Department will furnish this material in its original position, royalty free, to the contractor.

If any aggregate surfacing material is deficient in binding quality, or grading characteristics, an approved amount of binder shall be added, provided, however, that the grading of the final mixture shall not exceed the limits specified for the particular type and grading of aggregate surfacing. No binder shall be added, either upon the roadway or through the plant, until tests have been completed and the material approved for use by the laboratory. Quantities of binder, and haul thereon, when included in the contract, are not guaranteed to be used or required and the Department reserves the right to increase, decrease or omit all or any part of these items and no compensation will be allowed by reason thereof.

Binder, when required, shall be added at the plant or on the roadway. If added on the roadway, the binder shall be spread uniformly across the roadway over the loosely spread surface course layer in the amounts as directed. It shall then be thoroughly blended and mixed into the surfacing material by approved methods and equipment. Where the depth of the course is three inches or less, unless otherwise specified, the binder shall be processed into the entire depth. Where the depth of the course exceeds three inches, the binder shall be processed into not less than the upper three inches.

(C) Sources of surfacing materials shall be furnished by the contractor, unless otherwise specified. Should the contractor elect to produce these surfacing materials from Department controlled source or sources, he may do so at no cost or royalty.

20.03 EQUIPMENT.

(A) Crushing Equipment. Crushers shall have the capacity to break

rock fragments or boulders passing a screen with ten inch square openings. Crushing plant screening equipment shall be fitted, when required, with blowers or other devices capable of removing excess and undesirable fines.

(B) Aggregate Spreader. The equipment used for spreading the aggregate or surfacing material must be of a type approved by the engineer. If a mechanical spreader is to be used, it shall be capable of spreading one-half the width of the course at one time to a specified depth, providing the total width is not over 28 feet. The spreader need not be able to spread more than a 14 foot width.

(C) Screening Plants. Screening plants shall consist of a revolving trommel screen, shaker screen, vibrating screen, or other devices capable of removing oversize material, excess and undesirable fines.

(D) Motor Graders. Motor graders shall meet the requirements of Article 16.02(B).

(E) Rollers. Rollers shall meet requirements for the particular class of work designated in Article 13.12.

(F) Scales, when required, shall be furnished by and at the expense of the contractor. They shall be satisfactory to the engineer and shall be tested and sealed at the expense of the contractor prior to their use on the project and as often thereafter as the engineer may consider necessary to insure their accuracy. The contractor shall have on hand not less than ten 50 pound weights for testing scales.

The recording devices of the scales shall be housed in a suitable manner and the scales shall be so located as to facilitate accurate weighing of loads. The scales shall be accurate to one-half of one percent at any weight. Alternate methods or devices for weighing may be acceptable provided that these methods or devices produce the same degree of accuracy as required of platform scales.

The specifications for acceptance of platform and belt conveyor scales shall be as follows:

(1) Platform Scales. Platform scales shall be of sufficient size and capacity to weigh an entire non-trailer vehicle in an unbroken operation. Truck-trailer combinations may be weighed in separate operations providing the approaches to the scales are hard surfaced and level with the weighing platform and of sufficient length to accommodate the entire truck-trailer unit. All brakes shall be released during the weighing operation.

(2) Belt Conveyor Scales: Conveyor belt weighing will be accepted for non-asphaltic materials only, provided that this method or device shall meet the general requirements of weighing equipment and the following:

- (a) All belt-conveyor scales shall conform to the requirements for Belt Conveyor Scales as specified in the National Bureau of Standards, except as modified by these Specifications.
- (b) A daily Static load test shall be made after approximately one-half hour of continuous running of the belt-conveyor and whenever the air temperature varies 15° F. A chain test will be required, once daily, and whenever a need for adjustment has been determined by the daily static load test.
- (c) The test chain calibration computation, calibration procedures and results, and related documents shall be available for review by the Engineer. The test chain shall be clearly marked with its calibration. It shall be carried in a suitable container and shall be immediately available for testing of the belt conveyor scales.
- (d) Comparisons of accuracy shall be made by checking the average of five or more sequential hauling unit payloads on platform scales meeting the requirements of these specifications. A comparative accuracy of 0.5% (plus or minus) of the payload of the average hauling unit will be acceptable. Since the recording odometer of conveyor belt scales in general use is graduated to one-tenth ton (i.e 200 lbs.) increments, and since the recording is a cumulative process, minor differences in reading or variations smaller than one-tenth ton carry over from one vehicle unit to another. Confirmation of the conveyor weights will, for greater accuracy, be based on the tonnage values obtained from readings taken from the sealed odometer at the beginning and end of each check period. The number of check loads will be increased by the Engineer should the test results fluctuate.

The recording tape, odometer, totalizer, calibration adjustment (and clock-time imprinter, if so equipped) shall be secured and locked. All locking shall be done by and all keys shall be in possession of the Engineer, prior to any materials delivered to the roadway.

The recording devices of the scales shall be housed in a suitable manner and the scales shall be so located as to facilitate accurate weighing of loads. The scales shall be accurate to one-half of one percent at any weight. Alternate methods or devices for weighing may be acceptable in lieu of platform scales provided that these methods or devices produce the same degree of accuracy as required of the accepted platform scales.

20.04 PRODUCTION METHODS AND STOCKPILING. The contractor shall unless otherwise specified, provide for crushed gravel, crushed rock surfacing, cover material or stone chips containing as large a proportion as possible of crushed aggregate. The entire volume of oversize material in the source shall be passed through the various crushing or reduction units until such oversize has been reduced to the sizes specified. Oversize material retained on a screen having ten-inch square openings may be rejected. The crushed material should be combined with the screened material in such a manner that a uniform product will be obtained.

No surfacing material will be accepted which is loaded into hauling units in a segregated condition or which does not meet the required grading. In case the material deposit contains sand or other material, in excess of the specification gradation requirements, or of an unacceptable quality, such excess or undesirable material shall be removed and disposed of prior to crushing, or during screening operations, if crushing is not required. When production is from sources made available by the Department, material rejected in the manufacture of surfacing aggregate shall be disposed of as directed and will remain the property of the Department. Stockpiling of aggregates shall be done in accordance with the provisions of Article 26.04.

20.05 CONSTRUCTION METHODS.

(A) Surface Preparation. When the surfacing material is to be placed on a roadbed previously completed under a separate contract, the existing roadway surface shall be prepared in accordance with the requirements of subsection 19.20, immediately prior to placing surfacing under the current contract.

In the case of surfacing material being included in a contract involving grading and aggregate surfacing construction existing surface preparation shall be performed and in conformance with the provisions of that contract.

(B) Placing. No surfacing material shall be placed upon a frozen, wet, muddy, or rutted surface, subgrade or gravel, unless otherwise directed. Depositing and spreading of the material on the prepared subgrade or existing surface or on a completed surfacing course shall commence at a point on the roadway farthest from the from the loading source, unless otherwise directed, and shall progress continuously. The material shall be deposited upon the subgrade or preceding course of material in a uniform manner, approved by the engineer, insuring the ultimate planned thickness of the course being placed, following its final spreading and compaction.

If the required compacted depth of any aggregate surfacing course exceeds six inches, it shall be constructed in two or more layers of approximately equal thickness. The maximum compacted thickness of any one layer shall not exceed six inches.

The material shall be deposited and spread in a uniform layer, with no segregation of size, and to such loose depth that when compacted, due allowances have been made for any filler that is to be blended on the road. The layer shall have the required thickness.

Unless otherwise specified, the contractor shall mix the surfacing material by one of the three following methods and if required, add the additive shown on the plans.

(1) Stationary Plant Method. The surfacing material and water shall be mixed in an approved mixer. Water shall be added, as directed, during the mixing operation in the amount necessary to provide the optimum moisture content for compacting. After mixing, the material shall be transported to the job site while it contains the proper moisture content and shall be placed on the roadbed by means of an approved aggregate spreader.

(2) Travel Plant Method. After the material for each layer of surfacing course has been placed through an aggregate spreader or windrow sizing device, the surfacing material shall be uniformly mixed by a traveling mixing plant. During the mixing, water shall be added, as directed, in an amount sufficient to provide the optimum moisture content for compacting.

(3) Road Mix Method. After material for each layer of surfacing course has been placed, the materials shall be mixed while at optimum moisture by means of motor graders or other approved equipment until the mixture is uniform throughout.

When directed, the material shall be watered during the process of mixing. Each layer of material, after mixing to uniform gradation, shall be spread smooth without segregation of size to conform with the typical section shown on the plans and thoroughly compacted by rolling, supplemented by watering, if directed, before the succeeding layer is placed.

Aggregate spreaders, conforming to Article 20.03 (B) or other equipment performing satisfactory spreading work may be used, subject to the approval of the engineer. Equipment that does not maintain a uniform gradation of material for the entire width and thickness shall be corrected or removed from the work. The aggregate may be watered to optimum moisture content prior to or after crushing and loading in conveyance vehicles. If the engineer decides that the gradation of the material or the

moisture content, or both, provides a material that cannot be uniformly spread by a mechanical spreader, the use of the spreader shall be discontinued. The end results specified in preceding paragraphs shall be attained regardless of methods used in placing and compacting.

The operation of blending binder shall be performed in accordance with Article 20.02 (B).

(4) Control Strip Method. The density of surfacing aggregates, if called for on the plans or special provisions shall be determined at the beginning of compaction operations by compacting a control-strip approximately 100 feet long, at the direction of the engineer.

The thickness of the control-strip will be determined by the engineer. The moisture content of the material shall be maintained near optimum, and the control-strip compacted with rollers meeting the applicable requirements of Subsection 13.10 until there is no appreciable increase in density. No individual test shall be less than 95% of the determined density. The remainder of the course shall be divided into test sections, each approximately 2000 feet long. The same layer thickness, placing, compaction, watering and procedures used in constructing the control-strip shall be used on the test section. Each test section shall be compacted until its average density is at least 98 percent of the control-strip density.

The surface of each layer shall be maintained, during the compaction operations, in such a manner that a uniform texture is produced and the aggregate firmly keyed.

The contractor shall construct a new control-strip if the aggregate characteristics change appreciably during the construction of the project. A new density requirement will then be established and used as the control-strip density.

Moisture and density will be determined in accordance with the applicable provisions of Montana Test Method MT-210, 212, 215, 218 and 219.

(C) Watering. Watering shall be performed in accordance with subsection 13.50. The aggregate may be watered to optimum moisture during, or after, crushing. Water deemed by the engineer to have been wasted shall not be measured for payment.

(D) Compaction. Unless otherwise specified, the subgrade and all surfacing materials shall be compacted in accordance with Section 13. The material shall be processed and spread as closely behind the dumping units as is practicable.

(E) Restrictions. In addition to the restrictions imposed by State and Federal laws on the speed, size and weight of vehicles, weight of loads and

tire equipment, used in the connection with the prosecution of work, the engineer may further restrict the speed of the hauling units and the weight of loads as he may find necessary to prevent damage to the previously constructed subgrade, base, surface course or courses, or public thoroughfares used in the prosecution of the work.

20.06 SURFACE SMOOTHNESS.

The surface of a course of aggregate surfacing material, when finished, shall not vary above or below the grade established by the engineer by more than 0.08 foot when the specified maximum gradation of the aggregate is more than 1½ inches, and by more than 0.06 foot when the specified maximum gradation of the aggregate is from 1½ inches to three-quarters inches and by more than 0.04 foot when the specified maximum gradation of the aggregate is three-quarters inches and under.

The surface of the aggregate surfacing course when finished, shall be such that when tested with a ten foot straightedge placed on the surface parallel to the centerline of the roadway, the maximum deviation of the surface from the plane of the straightedge shall nowhere exceed one-half of one inch. Should patching of the course be necessary, in order to meet such tolerance, it shall be performed by using methods approved by the engineer and material the same as in the course being repaired.

20.07 METHOD OF MEASUREMENT.

(A) Binder which has been added to the surfacing material after it has been placed upon the roadway will be measured in accordance with the appropriate provisions of par. (C).

(B) Haul on Binder will be measured in accordance with Article 12.52.

(C) Any aggregate material used as surfacing will be measured by the cubic yard or by the ton, for the type of material stipulated in the contract. When measured by the cubic yard, measurement will be made of the loose material in the vehicle at point of delivery on the road. In order to aid checking of loads, the contractor shall strike or level any load, when directed to do so. When measured by the ton, the material shall be weighed on scales of the type prescribed in Article 20.03. When necessary to remove oversize material from the roadway, resulting from the placing of surfacing material, the quantity of such oversize material will be measured by the cubic yard or by the ton, as the case may be, returned to the aggregate source and it will be deducted from the total quantity of surfacing material placed on the roadway.

Payment for aggregate, measured by the ton, will be based on the scale

weight of the material, which weight will include the actual quantity of natural moisture, up to and including a five percent moisture content. Water, added at the direction of the engineer by the contractor, above the natural moisture content, will be deducted from the weight of aggregate and paid for as a separate item. Material containing more than five percent natural moisture shall have the excess above five percent deducted from the scale weight, according to the procedure described below.

Moisture determinations will be made on the dry basis as follows:

Weight of wet sample minus Weight of dry sample = Weight of water.

Weight of water in sample

x 100 = Percent moisture

Weight of dry sample

(D) Rolling, Watering, Hauling and other contract items will be measured in accordance with the respective sections or subsections, with the exception of "Control Strip Methods" for which no measurements for work involved in the construction, watering, compaction and maintenance will be made.

(E) Existing Surface Preparation when specified, will be measured by the unit or units and other items required for the work, as stipulated in the contract in accordance with the methods prescribed in subsection 19.20 for the respective items. When not stipulated, existing surface preparation will be considered incidental and necessary to the performance of the other items of the contract.

20.08 BASIS OF PAYMENT.

(A) Binder will be paid for at the contract unit price, which price and payment, except as otherwise expressly provided, will be full compensation for all material, labor, equipment, tools and incidentals necessary to complete the item and for all work, equipment and incidentals necessary in stripping overburden and restoring the source from which binder has been obtained to a status satisfactory to the property owner and the engineer.

(B) Haul on binder will be paid for at the contract unit price, which price and payment will be full compensation for the work.

(C) Aggregate material used as surfacing incorporated into accepted work will be paid for at the contract unit price, which price and payment, unless otherwise specified, will include furnishing all materials, production, handling, hauling, mixing, placing and spreading all materials and for all other charges; for maintenance of the completed surface until acceptance and for all other operations necessary to complete the work.

(D) Rolling, Watering, Hauling and other items will be paid for at the contract unit price in accordance with the requirements of the respective sections or subsections with the exception of "Control Strip Method". Payment for all work involved in the construction, watering, compaction and maintenance of each control-strip and each test section shall be absorbed in the contract unit price for the respective surfacing aggregate.

(E) Existing Surface Preparation will be paid for at the contract unit, or units, price or prices for other items required which prices and payment will constitute full compensation for the work. Unless otherwise provided, existing surface preparation will not be paid for directly but will be considered incidental to and absorbed in payment for the other items of the contract.

SECTION 21

VARIOUS SURFACING TYPES

SUBSECTION 21.00 SELECTED SURFACING

21.01 DESCRIPTION. Selected Surfacing shall consist of one or more courses of aggregate surfacing composed of the grade or maximum size of material stipulated in the contract or shown on the plans, constructed on the roadway in conformity with these requirements and the specifications and plans.

21.02 MATERIALS.

(A) Selected Surfacing material shall conform to Article 20.02 (A), M-100.03, and to the particular maximum size stipulated in the contract or shown on the plans. Pit run material shall be included.

(B) Binder, if required, shall meet the requirements of Article 20.02 (B).

21.03 EQUIPMENT, PRODUCTION METHODS, CONSTRUCTION METHODS, METHOD OF MEASUREMENT AND BASIS OF PAYMENT. Unless otherwise provided for in the Plans, Special Provisions, or this Section—the specific items shall meet the requirements of and be measured and paid for in conformity with the provisions of Section 20.

SUBSECTION 21.50 SAND SURFACING

21.51 DESCRIPTION. Sand Surfacing shall consist of one or more courses of sand composed of material stipulated in the contract or shown on the plans, constructed on the roadway in conformity with these requirements and the specifications and plans.

21.52 MATERIAL

(A) **Sand Surfacing** shall meet the requirements of Article 20.02 (A), M-100.04 and to the particular specifications for the type and size of grade stipulated in the contract and as shown on the plans.

Sand Surfacing shall conform to other requirements that may be

stipulated in the contract, which requirements may modify or amend these specifications and which may be developed upon specific job conditions or source of material.

(B) **Binder**, if required, shall meet the requirements of Article 20.02 (B).

21.53 CONSTRUCTION METHODS. The sand material shall be deposited upon the roadway and spread with blade graders or other approved equipment as to insure the ultimate planned thickness of the layer being placed following its final spreading and compaction. The material in any sand course shall be placed in horizontal layers of not more than six inches compacted thickness unless otherwise directed. The sand shall be kept at optimum moisture prior to, during and after spreading and while compacting.

Immediately after placing, the sand material shall be covered with the specified surfacing meeting the requirements of the plans and specifications. The sand material shall not be placed further than 1,000 feet in advance of the succeeding course of surfacing.

21.54 EQUIPMENT, PRODUCTION METHODS, CONSTRUCTION METHODS, METHODS OF MEASUREMENT AND BASIS OF PAYMENT. Unless otherwise provided for in the Plans, Special Provisions, or this Section — the specific items shall meet the requirements of and be measured and paid for in conformity with the provisions of Section 20.

SECTION 22

PORTLAND CEMENT TREATED BASE

22.01 Description. This work shall consist of constructing one or more courses of a mixture of aggregate and Portland cement on a prepared surface in accordance with these specifications in reasonably close conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the Engineer.

Unless otherwise provided, the Contractor may use either the travel plant or central plant method as described below.

22.02 MATERIALS.

(A) Portland Cement. Portland cement shall meet the requirements of AASHTO M-85, Type I-II. Bulk cement may be used provided the equipment for handling, weighing and spreading is approved.

(B) Water. Water used in the construction of this base course shall be from a source approved by the Engineer and shall meet the requirements of Article M-340.01.

(C) Mineral Aggregate. The mineral aggregate shall be obtained from approved sources. It is the intent of this specification to use the material from the approved sources subject to the following stipulations:

Extreme care shall be used in removing the mineral aggregate, so that it is not contaminated with deleterious overburden or from lower or adjacent material in order that a uniform product will be placed on the roadway.

The maximum size, grading and quality of the mineral aggregate shall meet the requirements set forth in the special provisions.

Whenever the word "aggregate" alone is used hereinafter, it shall mean "mineral aggregate."

22.03 COMPOSITION AND PROPORTIONING.

(A) Cement. Portland cement shall be applied at the rate determined by the engineer for the particular aggregate to be used. The approximate quantity is shown on the plans. No processing of the base shall be started until all tests of the base material to be used have been completed and the exact quantity of the cement required for the particular aggregate has been determined.

The produced material shall be available for sampling at least 60 days before processing.

(B) Water. The quantity of water required shall be the amount necessary for optimum moisture content plus or minus two percentage points in the compacted mixture. The quantity will vary with the nature of the aggregate and will be determined by the engineer.

22.04 CONSTRUCTION METHODS.

(A) Preparation. The previously prepared subgrade, meeting the requirements of Articles 11.03 and 11.04, shall be firm and able to support without undue displacement the construction equipment and have the density as required by Article 11.05. Soft or yielding subgrade shall be corrected and made stable before construction proceeds.

Any machine, combination of machines, equipment, or an approved central mixing plant may be used to produce the cement stabilized base course.

Regardless of what method of mixing is used or what types and combinations of mixing machines may be used, the results shall be as specified herein.

The machines and equipment used shall be in suitable operating condition and must be approved prior to use. During construction operations, the contractor shall maintain all equipment in proper working order and adjustment and shall make needed resetting or readjustment of the equipment, whenever required by the Engineer. If the equipment proves inadequate to obtain the results specified, such equipment shall be made adequate or other equipment shall be substituted which will obtain the specified results.

(B) Pulverizing.

At the completion of moist mixing, any clods of material shall be broken up, such that a minimum of 80 percent of the material will pass a No. 4 sieve exclusive of gravel retained thereon.

(C) Methods of Mixing

(1) Method A — Mixed in Place.

(a) The length of roadway which can be scarified and pulverized at any time shall not exceed the length which can be completed in two working days unless written permission is given by the Engineer. A sufficient quantity of aggregate shall be deposited and spread upon the previously prepared subgrade to form a base of the required compacted

depth shown on the plan for the full width of base course and shaped to the specified section and grade.

(b) Application of Cement. The required quantity of Portland cement shall be spread uniformly in an approved manner. Spreading of Portland cement shall be subject to the following restrictions: (The term "cement mixture" used herein shall mean "mixture of cement, mineral aggregate and water").

No cement shall be applied when the moisture content, of the loose aggregate, exceeds by more than three percentage points the specified optimum for the aggregate cement mixture, or when the moisture content of the aggregate will not permit a uniform and intimate mixture with the cement.

No cement shall be applied until the subgrade is capable of withstanding, without displacement, the compaction specified for the cement mixture.

No equipment, except that used in spreading and mixing, will be allowed to pass over the freshly spread cement. Any spreading and mixing equipment traveling over the spread cement shall be maintained at slow speed and any cement displaced shall be replaced before mixing is started.

No cement shall be applied during periods of high winds which may occasion the loss of cement unless the contractor provides equipment capable of drilling the cement into the aggregate without loss.

(c) Weather Limitations. No cement treating work shall be carried on during the season of probably freezing temperatures. No cement shall be applied unless the temperature is at least 40 degrees F. and rising.

(d) Mixing. Immediately after the cement has been distributed it shall be mixed with the loose aggregate for the full depth of treatment. Care must be exercised that no cement is mixed below the desired depth. Mixing shall be continued until a uniform and intimate mix of aggregate and cement is obtained. Any mixture of aggregate and cement that has not been compacted and finished shall not remain undisturbed for more than 30 minutes.

(e) Application of Water. Water supply and equipment shall be provided which will permit the continuous application of water on the section being processed. A portion of the water may be incorporated in the aggregate base course prior to addition of the cement. Immediately after mixing of the aggregate and cement is complete, the moisture content of the cement mixture will be determined by the Engineer and, if required,

water shall be applied uniformly in such quantities and at such a rate as he may direct. Each application of water shall be partially incorporated by the equipment.

After the last application of water, mixing shall be continued by using sufficient equipment to distribute the water uniformly throughout the full depth of the mixture in one operation. Particular care shall be exercised to insure satisfactory moisture distribution along the edges of the section.

(2) Method B — Central Plant Mixed. The aggregate, cement and water shall be mixed in a pugmill, either of the batch or continuous-flow type. The plant shall be equipped with feeding and metering devices which will add the aggregate, cement and water into the mixer in the specified quantities. Dry aggregate and cement shall be mixed sufficiently to prevent cement balls from forming when water is added. Mixing shall continue until a uniform and intimate mixture of aggregate, cement and water is obtained. Protective covers for hauling vehicles may be required.

The mixture shall be placed on the moistened subgrade in a uniform layer by an approved spreader or spreaders. The use of spreading or mixing equipment that will not result in a mixture of uniform density for its entire depth, immediately prior to compaction, will not be permitted. Not more than 30 minutes shall elapse between the placement of cement-stabilized mixture in adjacent lanes except where separated by longitudinal construction joints. The mixture shall be uniform in thickness and surface contour, and in such quantity that the completed base shall meet the required grade and cross-section.

Not more than 60 minutes shall elapse between the start of moist mixing and the start of compaction of cement-stabilized mixture.

(D) Moisture-Density Tests. The moisture and density relationship shall be determined by Montana Test Method M.T.-211. The density to be obtained in the base under the specifications shall not be less than 96 percent of the maximum dry density as determined above.

A final moisture density test will be made on samples of the moistened aggregate-cement mixture from the roadway to determine final moisture and density requirements.

The quantity of moisture in the completed mixture shall not vary from the optimum moisture content by more than two percentage points.

(E) Compaction. The choice of equipment for compaction is left to the contractor. If any equipment proves inadequate to obtain the results specified, such equipment shall be made adequate or other equipment shall be substituted which will obtain the specified results. The mixture

shall then be uniformly and continuously compacted until the entire width and depth of the cement stabilized base, in the lane being processed, is compacted to the density specified in Part (D) above. Compaction shall be accomplished within two hours after mixing is completed. If the compaction is less than that specified, two additional determinations will be made in the section and the results averaged. Should the average of the three determinations fail to meet the requirements, the section shall be reconstructed, at the contractor's expense, including materials.

If reconstructed after three hours from the time mixing is complete 100 per cent of the original cement content shall be added unless tests indicate this amount not required.

(F) Finishing. After the cement-treated mixture is compacted, the surface of the base shall be reshaped to the required lines, grades, and cross sections.

When required, the surface shall be scarified in order to loosen any imprints left by the spreading, compacting and shaping equipment and the resulting surface thoroughly compacted. The moisture content of the surfacing material shall be maintained at not less than its specified optimum during all finishing operations. Water shall be applied in a uniform fog spray to prevent loss of fine aggregate and cement. Finishing and compaction shall be accomplished in a manner to provide a smooth dense surface free from compaction planes, cracks, irregularities or loose material. The surface finishing shall be completed within two hours after completion of the compaction.

(G) Construction Joints. A straight transverse construction joint shall be formed at the end of each day's construction by cutting back into the completed work to form a true vertical face. When the width of the machine, or machines, is less than the width of the roadway lane being processed, the work shall be carried forward in successive increments so the lane may be compacted and finished for the full width in one operation.

Each day's run shall end in a single, straight line at right angles to the centerline of the roadway. Widths of base construction lanes shall be approved by the Engineer in order to expedite the movement of traffic during construction. The longitudinal joint for the construction lane shall be formed by cutting back into the completed work to form a true vertical face, free of loose and shattered material. Finished portions of the base course, adjacent to construction, which is traveled by equipment used in constructing an adjoining section shall be protected in such a manner to prevent equipment from marring or damaging the completed work.

(H) Stockpiling. Stockpiling mineral aggregates shall meet the requirements of Article 26.04.

22.05 GENERAL REQUIREMENTS.

(A) All placing, compacting and finishing operations in a specific area shall be completed in one eight hour work day.

If the uncompacted cement mixture is wetted by rain so that the average moisture content during compaction exceeds the tolerance specified by Article 22.04 (C) (1) (e) the entire section shall be reconstructed in accordance with Article 22.04 (E). The contractor shall receive no additional compensation for such reconstruction, or for the cement required.

(B) Surface Smoothness. The surface of the cement treated base shall be such that, when tested with a ten foot straightedge placed on the surface parallel to the roadway center line, the maximum deviation of the surface from the edge of the straightedge shall nowhere exceed three-eighths of an inch. Patching of the surface will not be permitted.

Surface irregularities not conforming to the above requirements shall be corrected, with a blade adjusted to its lightest cutting position, no later than twelve hours after the completion of compaction and finishing.

The material removed may be placed in lieu of aggregate for shoulder construction subject to the following conditions:

(1) The shoulder subgrade shall be prepared as specified in Article 22.04 (A).

(2) Hardened chunks of trimmed materials shall be removed or reduced to the maximum size specified for shoulder aggregate prior to spreading additional shoulder aggregate.

(3) The amount of trimmed material incorporated in the shoulder shall not exceed 25 percent of the planned depth of shoulder aggregate per linear foot of shoulder. When trimmings exceed this limit, the excess shall be removed and may be placed in other shoulder areas, in conformance with the 25 percent limit.

(4) The excess material shall be uniformly distributed in the shoulder area prior to spreading additional shoulder aggregate.

(C) Thickness. The thickness of finished cement treated base will be determined from measurements taken in test holes drilled at intervals not to exceed 500 feet. The average thickness of base constructed during one day shall not be less than one-quarter inch of thickness from that shown

on the plans, and the thickness at any one place shall be no less than one-half of an inch from that shown on the plans.

Where the average thickness shown by the measurements made in one day's construction is not within the tolerance specified or limited areas are deficient in excess of one-half inch from the plan thickness, the contractor shall reconstruct the deficient areas at no cost to the Department.

(D) Protection and Curing. After the cement treated base has been finished as hereinbefore specified, it shall be covered with a bituminous curing seal as called for on the plans or in the contract. The curing seal shall be applied at a rate of approximately 0.2 gallons per square yard. When so directed, blotter material conforming to the requirements of the Special Provisions shall be applied at approximately 15 pounds per square yard. The exact rate of application of the curing seal and blotter material shall be as directed to give complete coverage without excessive run-off. The surface of the cement treated base shall be kept continuously damp between the time of the final completed compaction and the application of the curing seal.

At the time of the application of the curing seal, the surface of the base shall be tightly knit, free of all loose material, and shall contain sufficient moisture to prevent penetration of the asphalt. If necessary sufficient water to fill the surface voids shall be applied immediately before the curing seal is applied. Areas which absorb the curing seal within 24 hours after application shall be cleaned to hard cement stabilized base, remoistened if necessary and given an additional application of curing seal, as directed.

The application of the curing seal, together with the one application of blotter material as directed, shall meet the requirements of Section 34.

(E) Maintenance. The contractor shall maintain the base to a true and satisfactory surface until the wearing course is placed. Should repairs or patching be necessary they shall extend to the full depth of the base and shall be made in a manner to insure restoration of a uniform base course meeting the requirements of the specifications.

(F) Traffic. No traffic, except incidental to curing operations, shall be permitted on the finished base for seven days after the curing seal cover has been completed.

(G) Curing Limitations. (1) A bituminous wearing course shall not be placed until the cement-treated base has cured at least 21 days after the curing seal has been applied. (2) A Portland cement concrete pavement shall not be placed until the cement-treated base has cured at least seven days after the curing seal has been applied.

22.06 METHOD OF MEASUREMENT.

(A) Cement will be measured by the short-ton or hundred-weight. Measurement will include the cement in the trimmings used as shoulder gravel and in the completed and accepted cement treated base. A short-ton shall be considered to be 2,000 pounds and a hundred-weight to be 100 pounds.

(B) All measurements to establish the pay quantity for cement treated base shall be within the dimensions shown on the plans and drawings. Cement Treated Base shall be determined as the number of surface square yards incorporated in the completed and accepted Cement Treated Base within the specified dimensions.

Gravel used in trimmings and lateral support sections outside the planned typical section dimensions will not be measured or included for payment. This excess material may be uniformly distributed on the shoulders or may be used at other locations in the work provided said excess material complies with the applicable specification requirement, or shall be otherwise disposed of as directed by the Engineer.

(C) The Curing Seal will be measured by the gallon or ton, applied to the cement treated base course, in accordance with Article 34.06.

(D) Blotter Material when called for, will be measured by the number of tons or cubic yards specified, for blotter material actually applied and accepted, in place, on the curing seal.

22.07 BASIS OF PAYMENT.

(A) **Cement.** The accepted number of short-tons or hundred-weights of cement measured as provided above, shall be paid for at the contract unit price per short-ton or hundred-weight. This price and payment shall be full compensation for furnishing, hauling, spreading if necessary, and for all equipment, tools, labor and incidentals necessary to complete the item.

(B) **Cement Treated Base.** The quantity of completed and accepted Cement Treated Base, measured as provided, shall be paid for at the contract unit price per square yard. This price and payment shall be full compensation for furnishing all work and materials, for preparation of the roadbed, for scarifying, pulverizing and drying the aggregate (if required) for mixing and remixing the aggregate, water, for shaping and compaction of the mixture; for reconstructing deficient sections; for finishing and for all protection and maintenance of the completed treated

base, and for all equipment, labor, tools and incidentals necessary to complete the items except cement, blotter material, and curing seal.

(C) Curing Seal. The accepted number of gallons or tons of curing seal, applied to the cement treated base as specified, will be paid for by the gallon or ton, as specified in accordance with Section 34.

(D) Blotter Material. The accepted number of tons or cubic yards of blotter material, measured as specified will be paid for at the contract unit price for blotter material.

[illegible]

SECTION 25

CRUSHED COVER AGGREGATE

25.01 DESCRIPTION. "Crushed Cover Aggregate" shall consist of Cover Material, stone chips or white chips meeting the requirements of these respective specifications and of Article 20.02. They shall either be placed on the roadway or stockpiled in accordance with the plans and specifications.

Materials placed in stockpiles shall meet the requirements of Section 26. Materials removed from stockpiles and used for bituminous surface treatment shall be done in accordance with the provisions of Section 32. Materials removed from stockpiles and used for seal coating shall be done in accordance with the provisions of Section 34. The contract unit price for bituminous surface treatment and seal coating shall include loading, weighing, hauling and applying, complete in place.

(A) Cover Material. Cover Material shall meet the gradation requirements of Article M-100.09 and, with the exception of the Table of Gradations, shall also meet the requirements of Article M-100.07.

(B) Stone Chips. Stone chips shall be screenings of crushed stone or crushed aggregate. They shall be durable fragments, reasonably clean and free from an excess of flat, elongated, soft or disintegrated pieces and shall meet the grading requirements of Article M-100.10. Stone chips as produced shall have a clean appearance, free from adherent films of clay or rock dust and shall be washed thoroughly unless otherwise provided in the contract.

(C) White Chips. White chips shall be produced from hard durable quartz or dolomitic marble, which has visible evidence of a preponderance of white colored mineral. They shall have a specific gravity of 2.5 or greater and shall be only slightly soluble in a cold 10% solution of hydrochloric acid.

Not less than 50% by weight of the material retained on No. 4 sieve shall have at least one fractured face.

White chips shall be washed clean and free from dirt and other deleterious substances. Washing of chips in the bed of the hauling vehicle will not be permitted.

Art. 25.07

When tested by Montana Test Method M.T.-202, the material shall meet the following specified grading requirements.

Percentages by weight passing square-mesh sieves:

PASSING	AMOUNT
2 inch sieve	100%
3/4 inch sieve	15-60%
No. 4 sieve	0-20%
No. 10 sieve	0-5%

25.03 EQUIPMENT AND PRODUCTION METHODS. Equipment and production methods for crushed cover aggregate shall meet the requirements of article 20.04 and 20.05.

25.04 CONSTRUCTION METHODS. If crushed cover aggregate is to be stockpiled at designated locations, the stockpiling shall be accomplished in accordance with Section 26. If crushed cover aggregate is to be placed on the roadway, the work shall meet the requirements of Sections 32, 34 or the Special Provisions.

All loose cover material shall be swept from the roadway surface before opening to traffic in accordance with the requirements of Article 34.04 (F). Additionally, sweeping as required, shall be done for a period of 10 days after the roadway has been opened to traffic. Sweeping may be accomplished by power brooms, blowers or hand brooming.

The excess cover material shall be swept off the sealed surface and onto the shoulders unless the engineer directs the material to be windrowed on the outer edges of the roadway for removal by State forces. Whenever curbs are encountered, the contractor will be required to load, haul and dispose of the excess cover material.

25.05 DISPOSAL OF EXCESS CRUSHED COVER AGGREGATE. See Article 09.09

25.06 METHOD OF MEASUREMENT. Crushed Cover Aggregate will be measured in accordance with Article 20.07.

25.07 BASIS OF PAYMENT. Cover Material, Stone Chips or White Chips will be paid for at the contract unit price placed in the stockpile or complete in place as may be specified, which price and payment, unless otherwise provided, will be full compensation for the work.

Payment, to the contractor, for sweeping excess cover material from the roadway surface will be included in other contract items.

SECTION 26

STOCKPILED SURFACING

AGGREGATE

26.01 DESCRIPTION. This specification provides for the production and stockpiling of aggregate surfacing at the sites designated in the contract or shown on the plans and as directed.

26.02 MATERIAL. The material shall meet the requirements of Article 20.02 and the particular specifications for the type and grade stipulated in the contract or as shown on the plans.

26.03 EQUIPMENT. Equipment shall meet the requirements of Article 20.03.

26.04 CONSTRUCTION METHODS

Stockpile sites shall be cleared of weeds, roots, stumps, rocks and other contaminating matter. The cleared matter shall be disposed of or leveled as directed. The site shall occupy a minimum area. The stockpile floor shall have a compact surface, be of reasonably uniform cross-section and shall adequately support the stockpile.

The area around completed stockpiles, built under maintenance contracts, shall be made neat in appearance. Spilled aggregate shall be neatly removed and disposed of as directed.

Stockpiles shall be constructed of at least three layers. Each completed layer shall be approximately four feet in height and shall be completed before the next layer is started. Material shall be placed in stockpiles by dump trucks or hauling units or cranes. Dumping over the sides of the stockpile is not permitted. Conveyor placement of stockpiles is discouraged and will be permitted only if the method of placement is submitted and has received approval. The Stockpile width shall be greater than the width of a single dump truck. Completed stockpiles shall have uniform top and side slopes and shall present a neat appearance.

Intermingling of aggregates from adjacent stockpiles, containing different grades, shall be prevented. Stockpiles with excessive segregation shall be remixed and re-stockpiled. Equipment, used in constructing

stockpiles or used to deliver stockpiled materials, that causes segregation or crushes the aggregate or introduces deleterious matter, shall be replaced or repaired or corrected. Stockpiled aggregate, determined to be out of specifications because of the unsatisfactory performance of the stockpiling equipment, shall be brought back within specifications at no expense to the Department.

26.05 METHOD OF MEASUREMENT.

(A) Stockpiled material will be measured at the stockpile site in accordance with the appropriate provisions of Article 20.07.

(B) Haul, when specified, will be measured in accordance with the appropriate provisions of Section 12.

26.06 BASIS OF PAYMENT.

(A) Stockpiled material will be paid for at the contract unit price, which price and payment, except as otherwise specified, will be full compensation for all materials, production, labor, equipment, tools, all manipulations and incidentals necessary to complete the work.

(B) Haul will be paid for at the contract unit price in accordance with the appropriate provisions of Section 12.

SECTION 30

PLANT MIX PAVEMENT

30.01 DESCRIPTION. These specifications include general requirements that are applicable to all grades of bituminous pavements of the plant mix type irrespective of gradation of aggregate, kind and amount of bituminous material, or pavement use. Deviations from these general requirements will be indicated in the specific requirements for each grade.

Plant mix pavement work shall consist of one or more courses of plant mix bituminous mixture constructed in accordance with these specifications and in reasonably close conformity with the lines, grades, thickness and cross-section shown on the plans or established by the engineer.

30.02 MATERIALS. (A) Composition of Mixtures. The bituminous plant mix shall be composed of a mixture of aggregate, filler if required and bituminous material. The gradation of the aggregate shall be specified in the contract or plans as Grade A, Grade B, Grade C or Grade D. The several aggregate fractions shall be sized, uniformly graded and combined in such proportions that the resulting mixture meets the grading requirements of the job-mix formula.

At least 15 days prior to mixing operations, the contractor shall submit representative samples of the proposed plant-mix aggregates and mineral filler to the laboratory for analysis and study.

The engineer will establish all job-mix formulas. The maximum permissible variation from the job-mix formula shall be as shown for each grade of plant mix. The permissible variations from the job-mix formula shall not permit the use of any mix which would be outside the specification limits, through the application of the variation.

A change in sources of aggregate materials shall require a new job-mix formula before the new material is used. Unsatisfactory results may require a new job-mix formula.

Individual gradation test results may vary from job-mix formula in amounts not exceeding the variations listed in Table I. In addition, the average of six consecutive tests or the number of tests run per eight hour shift, which ever represents the greatest amount of production, shall not vary from the job-mix formula by more than plus or minus 3.5 percentage points on the No. 4 sieve.

(B) Aggregate.**(1) General Requirements.**

(a) The aggregate shall meet the applicable requirements of Article 20.02 (A).

(b) The material, from which the aggregate is to be produced, shall have a wear factor not to exceed 50 percent at 500 revolutions, as determined by Montana Test Method MT-209.

(c) Not less than 50 percent by weight of the coarse aggregate particles shall have at least one fractured face.

(d) The liquid limit for that portion of the fine aggregate passing a No. 40 sieve shall not exceed 25 nor shall the plasticity index exceed six, as determined by Montana Test Method MT-208.

(e) The final produced aggregate including treated aggregate will be tested for volume swell. The tested material shall not have a swell of more than ten percent in eight days, and shall show no cracking or disintegration when tested for volume as determined by Montana Test Method MT-305.

(f) The composite aggregate shall be free from adherent films of clay or other matter that will prevent thorough coating of the rock with bituminous material.

(g) No intermediate sizes for cover aggregate or for other purposes shall be removed from the material in the course of production, unless authorized in writing by the engineer.

(h) Material retained on the No. 4 sieve shall be classed as coarse aggregate and material passing the No. 4 sieve shall be classed as fine aggregate.

(i) The aggregate for Grade A, Grade B, Grade C and Grade D, Plant Mix Bituminous Surfacing, including mineral filler when required, shall meet the requirements of Table I below.

TABLE I					Montana Test Method MT 405
Percentage by Weight Passing Square-Mesh Sieves					
Sieve Size	Grade A percent passing	Grade B percent passing	Grade C percent passing	Grade D percent passing	Job-Mix Variations
1"	100				
3/4"	90-98	100	100		
5/8"				100	Plus or Minus 7.0%
1/2"	75-90	80-100			Plus or Minus 7.0%
3/8"	60-80	70-90		75-100	Plus or Minus 7.0%
4M	40-55	45-65	45-70	50-72	Plus or Minus 7.0%
10M	30-40	32-45	25-55	35-50	Plus or Minus 4.0%
40M	15-28	15-25		16-28	Plus or Minus 4.0%
200M	3-8	4-10	2-10	5-11	Plus or Minus 2.0%
Asphalt Percent by Weight of Total Mix 4-7 Percent					Plus or Minus 0.4%

(2) Crushed Aggregate Stockpiles.

(a) General. Sites for aggregate stockpiles shall be grubbed and cleaned prior to storing aggregates. The site shall be firm, smooth and well drained. A bed of aggregate suitable to avoid the inclusion of soil or foreign material shall be maintained.

Crushed aggregate shall be separated into two or more general sizes and stockpiled. Screens used for the separation shall be the contractor's choice and may include slotted screens. However, no slotted screen shall be used that will permit passage of material that would normally be retained on a square opening equivalent to the maximum size of the aggregate being produced. Stockpiles shall contain within 30 percent of equal proportions of the total volume of aggregates.

When a representative volume of material has been produced, the engineer will determine the average percentage of material passing the No. 4 sieve in the coarse stockpile. This average percentage will be established as a target value to be maintained, within a tolerance of plus or minus seven percentage points for the remainder of the aggregate produced from that aggregate source for the coarse stockpile.

The coarse stockpile shall be built up in tiers of not more than four feet in thickness. Each tier shall be completely in place before the next tier is placed. No material shall be allowed to "cone" down over the next lower tier.

Dumping, casting or pushing over the sides of stockpiles will be prohibited except in the case of fine aggregate stockpiles.

Stockpiles of different gradations of aggregate shall be spaced far enough apart, or separated by suitable walls or partitions, to prevent the mixing of the aggregates.

Any method of stockpiling aggregate which allows the stockpile to become contaminated with foreign matter or causes excessive degradation of the aggregate will not be permitted. Excessive degradation will be determined by sieve tests of samples taken from any portion of the stockpile over which equipment has operated and failure of such samples to meet all grading requirements for the aggregate shall be considered cause for discontinuance of such stockpiling procedures.

The aggregate shall be transferred from the stockpiles in such a manner that uniform grading of the material is preserved.

(b) Conveyor Stockpiling. When coarse materials are stockpiled by conveyors, the material shall be deposited in a succession of merging-cone piles. No material shall be allowed to drop over twelve feet nor cones exceed 12 ft. in height. Prior to starting another tier, coned piles shall be leveled to a thickness of approximately four feet.

(c) Truck Stockpiling. When coarse materials are stockpiled by trucks, the stockpile shall be constructed in tiers, approximately four feet in thickness. Each tier shall be completed before the next tier is started. When it is necessary to operate trucks or other equipment on the stockpile it shall be done in accordance with the requirements of Section 26 and as approved by the engineer.

(3) Cold Feed Control.

The aggregate shall be recombined in the cold feed process in the proper proportions before being fed into the dryer.

At the contractors option aggregate degradation may be controlled through a cold feed control system permitting hot mix plant operation without plant screens with the exception of the scalping screen. Permission to continue under this option may be rescinded upon failure to maintain production within gradation limits.

Each individual aggregate shall be fed through a separate feeder that has a positive feed and that can be easily and accurately calibrated. The feed shall be quick adjusting and shall maintain a constant and uniform flow throughout the range of its calibration.

The point of acceptance for the physical properties of the aggregates will be in the stockpiles at the plant site. Acceptance testing for aggregate gradation will be performed just prior to the addition of bituminous material to the mixtures. An approved sampling device shall be provided at a point just prior to the aggregate entering the dryer, capable of sampling a representative composite sample.

(C) Bituminous Material. The bituminous material shall be the type and grade specified and shall meet the requirements of section M-120. The percentage of bitument in the mix will be determined by the engineer, based upon laboratory tests, sieve analysis and grading and character of the aggregate furnished within the specification limits. The upper limit of bitumen may be raised when using absorptive aggregates.

The contractor will not be allowed any claim for payment for the rejection of any batch or load of mixture which contains a quantity of bitumen varying more than four-tenths of one percent from the percentage as fixed by the engineer.

When hydrated lime is introduced into a paving mixture it shall be considered as a chemical additive and shall not be included in the test results for the percentage of material passing all sieves.

Anti-Stripping Additive. When the Department of Highways Laboratory tests so indicate, it shall be a requirement that a laboratory approved heat-stable, anti-stripping additive be blended into the bituminous material prior to application. The percentage of additive will be determined by laboratory tests on samples of the actual aggregate which the contractor proposes to use for construction of the project. The anti-stripping additive shall be combined with the bituminous material at the refinery by means of a proportioning device, or other approved means, in such manner that the additive will be uniformly distributed throughout the bituminous material.

The proposed quantity is not guaranteed to be used or required. The State reserves the right to increase, or omit all or any part of the anti-strip additive item and no compensation will be allowed by reason thereof.

30.03 MINERAL FILLER.

(A) Description and Scope. These specifications shall cover Mineral Filler for use in the construction of hot plant mix bituminous surfacing.

The proposed quantity is not guaranteed to be used or required. The State reserves the right to increase, decrease, or omit all or any part of the mineral filler item and no compensation will be allowed by reason thereof. The actual quantity and kind of mineral filler to be used shall be based on tests made with the various kinds of mineral filler on crushed aggregates produced for use in plant mix.

(B) Material.

(1) Mineral filler shall meet the requirements of Article M-340.07.

30.04 CONSTRUCTION REQUIREMENTS.

(A) Weather Limitations. The bituminous mixture shall not be placed on a wet surface, or an unstable roadbed, or when weather conditions prevent the proper handling or finishing of the mixture or when the base temperature is less than 20°F.

(B) Requirements For All Mixing Plants. Plants used for the

preparation of bituminous mixtures shall meet all the requirements for all mixing plants except that scale requirements shall apply only where proportioning by weight is used.

(1) **General.** Mixing plants shall be either the weight batching type, the continuous flow mixing type, or dryer drum type. All dryer drum mixers shall have been specifically designed and constructed for the process.

All types of plants shall be equipped with satisfactory conveyors, power units, aggregate handling equipment, aggregate screens and bins and shall be so coordinated and operated as to produce a mixture consistent within the job mix tolerance specified.

Mixing plants, batch or continuous, shall have a minimum production capacity of 100 tons an hour unless the engineer permits a plant of lesser capacity. Plants of a lesser capacity may be permitted for some types of urban work or work where the lower production rate is efficient and acceptable.

Mixing plants that are not capable of continuously producing a mixture meeting requirements as specified, shall not be used.

(2) **Mineral Filler.** If no provision is made to weigh the mineral filler in the weigh box at the mixing plant with the other aggregates, the proportions of mineral filler shall be determined on a weight basis and shall be measured separately from the other aggregates. After the proportions of mineral filler have been determined, the material may be added to the mixture at the mixing plant by volume or weight measurement.

The mineral filler shall be stored in a separate bin, and fed directly into the mixture in a manner that will provide complete mixing. The rate of feed shall be controlled to provide a uniform weight of mineral filler into each batch or load.

(3) **Storage and Heating Equipment.** Tanks for storage of bitumen shall have a total capacity sufficient for not less than four (4) hours run of the mixing plant and shall be capable of heating the bitumen, under effective and positive control at all times, to temperature requirements specified. The heating system shall provide uniform heating of the entire contents of tanks.

Storage tank shall have a positive means of measuring the quantity therein by gauge, calibrated rod or float.

Heating shall be accomplished by steam coils, electricity or other approved means. No flame shall come in contact with the heating tanks. The circulating system for bitumen shall be a closed system of adequate

capacity. It shall cause proper and continuous circulation during the entire operating period, have its own pump or pumps, and shall have no inlet or outlet pipe or drain into which fuel oil or similar material can be introduced.

(4) Feeder for Dryer. Plants shall be provided with accurate, mechanical means for uniformly feeding the mineral aggregate into the dryer. Uniform production shall be obtained.

(5) Bins. The plant shall be equipped with storage bins, protecting the aggregate from the weather, or sufficient size to adequately supply the mixer when it is operating at full capacity. Bins shall be so arranged that separate and adequate storage of appropriate fractions of aggregate is assured. Each bin shall be provided with overflow pipes, of such size and at such location as to prevent backing up of material into other compartments or bins. Each bin shall be provided with its individual outlet gate, designed and constructed so that when closed there will be no leakage and the gates will cut off quickly and completely.

Bins and access to the sampling area of bins shall be so constructed that representative samples can be readily and safely obtained. Separate dry storage shall be provided for mineral filler, when used.

(6) Bituminous Control Unit. Satisfactory means, either by weighing, metering or volumetric measurements, shall be provided to obtain the proper quantity of bitumen in the mix within the variation specified. Suitable means shall be provided for checking the quantity or rate of flow of bituminous material into the mixer. An armored thermometer or other approved thermometric equipment shall be fixed in the bitumen feed line at a suitable location near the charging valve at the mixer.

(7) Thermometric Equipment. Thermometric equipment shall have an adequate range in temperature reading, shall be accurate to plus or minus five degrees F. and shall be sensitive to a rate of temperature change of not less than ten degrees per minute.

(8) Dust Collector. The plant shall be equipped with a dust collector constructed to waste or return uniformly to the hot elevator all or any part of material collected as directed.

Scrubbers or similar devices shall be used when required by the Department of Health and Environmental Sciences. Liquids from a wet scrubber shall not be discharged into a live stream, lake or pond. The effluent shall be circulated through sludge pits or tanks. The resultant sedimentation, together with all other waste material developed by

crushing and mixing operations, shall be contained or otherwise acceptably disposed of, in connection with the reclamation work prescribed in Article 06.02 (E).

(9) Scales for Hauling Units. Scales for hauling units shall meet the pertinent requirements of Article 20.04 (F).

(10) Plant Scales. Scales shall be accurate to 0.5 percent of the maximum load that may be required. Poises shall be designed to be locked in any position and to prevent unauthorized change of position.

Scales for any weigh box or hopper may be either the beam or springless dial type and shall be of a standard make and design. Scales of the beam type shall have a separate beam with a tell-tale indicator for each size aggregate and a tare beam for balancing the hopper. The tell-tale indicator shall start to function when the load being applied is within 100 pounds of the load desired.

Dial scales shall be springless, of standard make, designed constructed and installed so that they will be maintained free from vibration, and of such size that the numerals on the dial may be read at a distance of at least ten feet. The dial shall be of the compounding type having full complements of index points. Pointers so placed as to give excessive parallax errors shall not be used. The scales shall be substantially constructed and, if not capable of maintaining positive adjustment, shall be replaced when so ordered. All dials shall be so located as to be plainly visible to the operator at all times.

All weighing equipment is subject to approval by the engineer and shall be capable of easy adjustment of any working part.

The contractor shall have on hand not less than ten 50 pound weights for testing scales. Scales shall be inspected and sealed as often as the engineer deems necessary to assure continued accuracy.

(11) Automatic Printer System. The contractor may provide an approved automatic printer system, in lieu of plant and truck scales, provided the system is used in conjunction with an approved automatic batching and mixing control system. An automatic printer system shall print the weights of materials delivered and such weights shall be evidenced by a weigh ticket for each load.

The recorded weight shall be accurate to 0.5 percent of the true weight. The engineer may require random loads to be checked on sealed scales.

(12) Safety Requirements. Adequate and safe stairways to the mixer platform and sampling points shall be provided and guarded

ladders to other plant units shall be placed at all points where accessibility to plant operations is required. Accessibility to the top of truck bodies shall be provided by a platform or other suitable device to enable the engineer to obtain sampling and mixture temperature data.

All gears, pulleys, chains, sprockets, and other dangerous moving parts shall be thoroughly guarded and protected. Ample and unobstructed space shall be provided on the mixing platform. A clear and unobstructed passage shall be maintained at all times in and around the truck loading area. This area shall be kept free from drippings from the mixing platform.

30.05 VACANT

30.06 BATCHING PLANT.

(A) Weight Box or Hopper. The plant equipment shall include a means for accurately weighing each size of aggregate in a weigh box or hopper suspended on scales and of ample size to hold a full batch without hand leveling or running over. The gate shall be close fitting, quick operating and shall close tightly. No material shall be allowed to leak into the mixer while a batch is being weighed.

The weigh box shall be so designed that the entire batch is discharged quickly and cleanly into the mixing unit. The weigh box shall be open at the top. If an excess of one size of aggregate is introduced into the weigh box, it shall be removed by the operator.

Automatic plants may proportion all aggregate by simultaneous measuring if a weight hopper with a separate compartment for each bin size, calibrated by weight, is used.

(B) Dryer. Plants shall include a dryer or dryers which continuously agitate the aggregate during the heating and drying process. The dryer shall be equipped with an approved dial scale and a mercury actuated thermometer, an electric pyrometer or other approved thermometric instrument. The thermometric instrument shall be placed at the discharge chute of the dryer and shall indicate or register automatically the temperature of the heated aggregate.

After drying, all transfer and conveyance of material shall be completed enclosed.

(C) Screens. Plant screens, capable of screening all aggregate to the specified sizes and proportions and having normal capacity in excess of the full capacity of the mixing unit, shall be provided.

If the contractor elects to control aggregate gradation through a cold

feed control system, as specified in Article 30.02 (B) (3), plant screens may be eliminated except for the scalping screen.

(D) Bituminous Control. The equipment used to measure the bituminous material shall be accurate to plus or minus 0.5 percent. The capacity of the bitumen bucket shall be at least ten percent greater than quantity of bituminous material required for each batch.

The bituminous material bucket, its discharge valve or valves and spray bar shall be adequately heated. Steam jackets, if used, shall be efficiently drained and all connections shall be so constructed that they will not interfere with the efficient operation of the scales. The bitumen bucket shall be a non-tilting type fitted with a loose, sheet metal cover. The bitument bucket shall be suspended on beam type scales equipped with a tell-tale that shows the tare weight of the bucket for each weighing. The net weight of the bitumen shall be measured to plus or minus 0.5 percent of the weight required. The plant shall have an adequately heated quick-acting, non-drip, charging valve located directly over the bituminous material bucket. The bucket shall be so arranged that it will deliver the heated bitumen in a thin uniform sheet or in multiple streams to full width of the mixing unit.

The indicator dial shall have a capacity of at least 15 percent in excess of the quantity of bituminous material used in a batch. The controls shall be constructed so that they may be locked at any dial setting and will automatically reset to that reading after the addition of bituminous material to each batch. The dial shall be in full view of the mixer operator. The flow of bituminous material shall be automatically controlled so that it will begin when the dry mixing period is over. All of the bituminous material required for one batch shall be discharged in not more than 15 seconds after the flow has started. The size and spacing of the spray bar openings shall provide a uniform application of bituminous material the full length of the mixer. The section of the bituminous line between the charging valve and the spray bar shall be provided with a valve and outlet for checking the meter when a metering device is substituted for a bituminous material bucket.

(E) Mixing Unit. The mixing unit shall be an approved type capable of producing a uniform mixture within the job-mix variation. The mixer box, if not enclosed, shall be equipped with a dust hood that prevents loss of dust.

The clearance of blades from all fixed and moving parts shall not exceed one inch unless the maximum diameter of the aggregate in the mix

exceeds 1 1/4 inches, in which case the clearance shall not exceed 1 1/2 inches.

The mixer box shall be equipped with a lock timing device that accurately controls the mixing cycle.

Control of time shall be flexible, permitting adjustment of cycles up to three minutes in five second intervals.

30.07 CONTINUOUS MIXING PLANT.

(A) Aggregate Proportioning. The plant shall include means for accurately proportioning each size of aggregate. Bins shall be equipped with tell-tale devices that indicate the position of the aggregate in the bins at the lower quarter points.

Each compartment bin being used shall provide a uniform head of aggregate. The plant shall have a feeder mounted under each bin. The feeding units shall provide a uniform flow of aggregate. Each compartment bin shall have an accurately controlled individual gate to form an orifice for volumetrically measuring the material drawn from each bin. The feeding orifice shall be rectangular with one dimension adjustable by positive mechanical means, provided by a lock. A cutoff system shall be used which automatically stops mixing operations when the minimum level in the bin has been reached. Each bin shall have an overflow spout to control the top level of the aggregate in the bin.

(B) Weight Calibration of Aggregate Feed. The plant shall include means for calibration of gate openings by weighing test samples. Provisions shall be made so that material fed out of individual orifices may be by-passed to individual test boxes. The contractor shall provide a platform scale of approximately 500 pounds capacity and containers of adequate size for weighing test samples drawn from the gates.

(C) Bituminous Control. The volumetric proportioning device for the bitumen shall be a rotating, positive displacement, bitumen metering pump with a satisfactory nozzle arrangement at the mixing unit. The operating speed of the pump shall be synchronized with the flow of aggregate to the mixing unit by an automatic inter-locking control. This control shall be capable of easy and accurate adjustment. Means shall be provided for accurately checking the rate of flow of bitumen into the mixture.

(D) Mixer Unit. The plant shall include a continuous mixer of an approved type, adequately heated and capable of producing a uniform mixture within the job-mix variation.

The mixer shall be equipped with a discharge hopper with dump gates

which will permit rapid and complete discharge of the mixture. The paddles shall be adjustable for angular position on the shafts and reversible to retard the flow of the mix. The mixer shall have a manufacturer's plate giving the net volumetric contents of the mixer at the several heights inscribed on a permanent gauge. Charts shall be provided showing the rate of feed of aggregate per minute for the aggregate being used.

The clearance of the mixer blades shall conform to Article 30.06 (E).

The plant shall be equipped with a surge hopper having positive acting gates at the end of the pugmill to provide for discharging the mixture in sufficient quantity to prevent segregation.

(E) Dryer. The requirements of Article 30.06 (B) also apply to continuous mixing plants.

30.08 DRYER DRUM MIXING PLANT.

(A) The cold feed control requirements specified in Article 30.02 (B) (3) shall be used with dryer drum mixing.

(B) Calibrated Cold Feed Proportioning. The cold feed shall be capable of being calibrated to assure full control of the mix gradation.

(C) Weight Measurement of Aggregate. Positive weight measurement of the combined cold feed must be maintained to allow regulation of the feed gate and permit automatic correction for variations in load.

(D) Synchronization of Aggregate Feed and Bituminous Material Feed. The bituminous feed control shall be coupled with the total aggregate weight measurement device in such a manner as to automatically vary the bitumen feed rate as necessary to maintain the required proportions.

(E) Automatic Adjustment. A method must be provided for automatically compensating the bituminous content in the mix for moisture variations in the cold feed.

30.09 ROADWAY EQUIPMENT.

(A) Pavers. Spreading, shaping and finishing of the surfacing course or courses of bituminized mixture shall be done by one or more self-contained self-propelled units or pavers, operated in such manner that no supplemental spreading, shaping or finishing will be necessary to provide the surface smoothness required. Pavers shall contain an integral, activated screed or strike-off assembly, heated if necessary, they shall be

capable of spreading and finishing the surfacing course to not less than the full width of a traffic lane and from three-quarters inch to six inches in depth, true to line, grade and crown of the section specified by the plans.

Extensions and cut-off shoes shall permit changes in widths by increments one foot or more.

The screed or strike-off assembly shall produce a finished surface of the required smoothness and texture without tearing, shoving or gouging. The unit or paver shall be provided with rolling, tamping or other suitable devices so as to produce a surface course uniformly dense throughout, smooth and free from inequalities and irregularities.

The screed shall be equipped with automatic grade controls which shall be used to make adjustments in both transverse and longitudinal directions.

The sensing device shall be adaptable to picking up grade information from a taut string line, beam or wire, rail, ski, mobile reference or travelling string line to adjacent strip or pavement. The rolling straight edge shall consist essentially of a cord, beam or wire stretched between shoes or wheels spaced at least 30 feet apart and attached to the paver. If a single ski is used, it shall be a minimum of 30 feet long. The device shall be of standard commercial quality adapted to the type of paver used and shall provide control for producing a uniform surface to the established grade, and a cross slope conforming to the requirements of the typical section. The system shall be designed to permit the grade reference device to operate on either side of the paver and shall be capable of maintaining the desired transverse slope regardless of changes in screed elevation. The device shall also be equipped with the necessary controls to permit the operator to adjust or vary the slope throughout superelevated curves.

In the event of failure of automatic controls the contractor will be permitted to finish the shift or not to exceed 4 hours, using manual controls but he will not be permitted to resume operations until the automatic controls are repaired. The use of the automatic controls may be waived on irregular sections or other sections where its use is deemed impractical.

The receiving hopper shall have sufficient capacity, shall avoid decreases in speed while receiving loads, and shall operate efficiently. Unnecessary delays in dumping trucks shall be avoided.

The paver shall include a device for forming beveled edges of the surfacing courses when required.

An Infra-Red generator shall be provided, if directed, for attachment to the side of each paver.

Pavers shall have power adequate for efficient operation on ascending

grades of seven percent while pushing a loaded truck. Pavers shall have quick, positive steering ability and operate at speeds commensurate with satisfactory placing of the surfacing course mixture.

The paver speed shall be commensurate with the rate of delivery of the mixture to the paver and shall be coordinated to provide a uniform rate of placement without intermittent operation of the paver.

(B) Trucks. The beds of hauling vehicles shall be tight, clean and smooth. Beds shall be sprayed lightly with limewater, or soap, or a detergent solution. Oil or diesel fuel shall not be used. Any excess solution remaining on a vehicle bed shall be properly disposed of before loading of that vehicle is permitted.

Any truck that causes excessive segregation, undue delays or shows detrimental oil leaks will be discharged from the work until such conditions are corrected. When necessary, each load shall be covered with canvas or other approved material of sufficient size to protect the mixture from dust, foreign materials or the weather. When necessary, truck beds shall be insulated and covers securely fastened to protect the mixture from excessive heat loss.

(C) Rollers. The type of roller used shall meet the requirements of Article 13.12 (B) and (D) except; approved types of vibratory rollers may be permitted. Pneumatic tire rollers shall have a minimum contact pressure of 60 psi, except; this pressure may be varied when the roller is used as the "breakdown" roller or when a tender mix is encountered or the engineer directs a lesser tire pressure be used.

All types of rollers shall be equipped with self cleaning devices and suitable means for evenly watering roller surfaces. Steel surfaces shall be free from flat areas, grooves or projections that would mar the surface of the pavement.

30.10 PREPARATION OF AGGREGATE.

(A) Batch and Continuous Flow Plants. Aggregates shall be dried and heated at the plant so that when delivered to the mixing unit they shall be at as low a temperature as is consistent with proper mixing and laying and in no case to exceed 325 degrees F. Flames used for drying and heating shall be properly adjusted. Heat shall not damage the aggregate. Visible unburned oil or carbon residue shall not be left on the aggregate.

Drying shall continue for a sufficient time and at a sufficiently high temperature, consistent with this specification, to cause the aggregate to become thoroughly surface dry. If the bituminized mixture contains evidence of excessive moisture, the production of the plant shall be

regulated in such manner that the aggregate can be properly dried.

If excessive moisture is indicated by; foaming on the surface of the coarse aggregate particles, excessive slumping of the mix in the truck, condensed water dripping from the truck box, bubbles or blisters forming on the surface immediately behind the paver, or any other visual indications, the engineer may require the moisture content to be lowered to as low as one percent.

Immediately after heating and drying, the aggregates shall be screened and conveyed into separate compartments ready for batching and mixing with bituminous material.

All aggregates shall be stored in a manner that controls the temperature within the limits prescribed for mixing and prevents accumulation of moisture. Additional natural materials (not mineral filler), if required to meet the grading requirements, shall be proportioned and blended with the aggregate before being screened into the separated bins. This natural material may be added to the aggregate at the mixing plant by premixing it thoroughly with the other fine aggregates or by feeding it into either the hot or cold elevator. Spreading this natural material over the tops of the aggregate piles or dumping it into the hoppers at crushing plants will not be permitted.

Aggregate shall be delivered to the plant from a stockpile or stockpiles, prepared before mixing operations. Stockpile construction shall be done in accordance with the provisions of Article 30.02 (B) (2). The quantity of stockpiled material shall be sufficient for at least one day of mixing plant operations. The mixing plant shall not be charged with aggregates coming directly from crushing or screening plants or combinations of these plants.

The aggregate for the bituminous mixture will be sampled for testing after drying and before bituminizing. Should there be any oversize material, or an excess of material passing the No. 200 mesh sieve, the mixing plant shall be so regulated that the oversize material and excess fine materials can be removed prior to preparing the bituminous mixture.

(B) Batch or Continuous Plants Operating Without Cold Feed Controls.

(1) Grades A, B & D Plant Mix Surfacing. Aggregate for Grades A, B and D Plant Mix Surfacing shall meet the requirements of Article 30.02 (A) and 30.02 (B) (1).

After the aggregate has been heated and dried and otherwise prepared as specified in Article 30.10 (A), it shall be separated by screening into at least three sizes and stored in separate compartments. At least one of the bins shall contain material passing the 10M sieve. The

other separations of the aggregate shall be between such limits as may be necessary to produce the mixture specified.

(2) **Grade C Plant Mix Surfacing.** Aggregate for Grade C Plant Mix Surfacing shall meet the requirements of Article 30.02 (A) and 30.02 (B) (1).

After the aggregate has been heated and dried and otherwise prepared as specified in Article 30.10 (A), it shall be separated by screening on the No. 4 M screen into at least two sizes and stored in separate compartments. The two sizes shall later be combined in the directed proportions upon charging the mixing unit.

(C) **Dryer Drums.** The moisture content of the bituminous mixture at discharge from the mixture shall not exceed three percent.

30.11 PREPARATION OF BITUMINOUS MIXTURE.

(A) **Batch and Continuous Flow Plans.** The hot aggregate shall be accurately measured and conveyed into the mixing unit in the proportionate quantities of each aggregate required to meet the specified grading. The aggregate shall be introduced into the mixing unit at a temperature of:

(1) Not more than 225 degrees F. when cutback liquid asphalt is used, and;

(2) Not more than 325 degrees F. when asphalt cement or slow-curing liquid asphalt is used.

IN NO CASE shall the asphalt be introduced into the mixing unit at 25° or more below the temperature of the aggregate.

The bituminous mixture, immediately after mixing, shall be within the temperature range specified in the data on "temperature-viscosity" furnished for the bituminous material used.

Mixing shall produce a homogenous mixture in which all aggregate particles are thoroughly and uniformly coated.

A mixture will be considered unsatisfactory if it shows an incorrect quantity of asphalt, has been injured or damaged by burning, is improperly mixed or does not meet specification requirements after mixing. An unsatisfactory mixture shall be disposed of before placement or removed and replaced if detected in the roadway, except; unsatisfactory material inadvertently placed in the roadway may be accepted if the quantities are small or the material is not detrimental to the roadway. Removing, replacing, or disposing of unsatisfactory material shall be at no cost to the State.

(B) Dryer Drums. Only the last paragraph of Article 30.11 (A) (2) applies to dryer drum mixing plants.

The temperature of the bituminous mixture at discharge from the mixer shall not exceed 250°F. The temperature of the mix at laydown shall be not less than 180°F. The actual mixing temperature shall be adjusted as directed by the engineer, within the allowable limitations, to best suit construction conditions.

If a satisfactory mixture is not obtained due to insufficient moisture in the aggregate, the contractor will be required to add moisture to the aggregate before introduction into the dryer-drum mixer at no cost to the State.

(C) Mixing Time.

(1) Batch Plant. After the required amount of hot aggregate has been introduced into the pug-mill mixer, hot asphalt shall be added. The materials shall be mixed until a uniform coating of the particles and a thorough distribution of the bituminous material throughout the aggregate is secured. The minimum mixing time shall be 25 seconds unless, at the discretion of the engineer, the contractor may be required to mix more than 25 seconds in order to obtain a satisfactory mix.

(2) Continuous Plants. The minimum mixing time shall be 25 seconds unless, at the discretion of the engineer, the contractor may be required to mix more than 25 seconds in order to obtain a satisfactory mix.

Mixing time in seconds equals "pug-mill dead capacity in pounds" divided by "pug-mill output in pounds per second".

30.12 CONSTRUCTION METHODS.

(A) Existing Surface Preparation. Preparation of the existing surface shall be performed in accordance with the pertinent requirements of Subsection 19.20.

(B) Prime Coat. When a coat of approved bituminous material is determined necessary, it shall be applied, prior to application of the plant mix material, at the rate directed.

The plant mix bituminous surfacing course shall not be placed until the prime coat has cured a minimum of 24 hours, or longer if directed.

Plant mixed bituminous surfacing material shall not be placed on any primed surface that contains an excessive percentage of moisture, as determined by the engineer.

(C) Protection of Traffic and Roadway Structures.

(1) Traffic protection shall be performed in accordance with the applicable provisions for traffic control.

(2) Protection of highway structures shall be performed in accordance with Article 32.05 (B).

All equipment shall be removed from the road at the conclusion of the day's work.

(D) Transportation and Delivery of Mixture. The bituminous mixture shall be transported in pneumatic-tired vehicles.

(E) Spreading and Finishing. Placing of the mixture shall be done on an approved surface. The mixture shall be spread, with pavers, over the entire width or such partial width as may be practicable. Material for shoulder widening may be placed with other approved equipment.

Whenever the planned compacted thickness of a plant mix bituminous surfacing course is 0.20 feet or less it shall be constructed in one course, unless specified otherwise on the plans or proposal. A planned compacted thickness of more than 0.20 feet shall be constructed in no less than two lifts, or as directed.

The engineer will establish horizontal alignment controls for spreading each course. The contractor shall set a string based on this control, and cause one edge of the first lane of each lift of surfacing to follow the string.

Plant mix material may be spread to the required thickness on small areas, irregular areas, approaches, turnouts, around manholes, inlets, walls and other areas not readily accessible by a paver, by motor grader, special pavers or by hand methods. Compaction of mix on such areas shall be done as directed. The compaction equipment used may be small self propelled rollers, trench rollers, vibratory tampers, heavy hand rollers or similar approved compactors.

Hauling over any plant mix surface course will not be permitted until the mixture has been properly compacted and has cooled to atmospheric temperature.

(F) Joints. Placing of each course shall be as continuous as possible. The width of each course shall be adjusted so longitudinal joints are offset by at least six inches in vertical planes. Transverse joints shall be offset at least six feet in vertical planes.

Longitudinal and transverse joints shall be formed with reasonable care and precision of workmanship. Ridges or depressions at joints, that exceed the surface tolerance, shall be corrected. Joints with accumulations of mud, dust or other foreign matter shall be cleaned or trimmed back as

directed before placing the adjoining material. The exposed face of all joints, except those formed by echelon paving, shall have a coat of SS-1 emulsified asphalt or other approved bituminous material applied just before placing the abutting course.

Longitudinal joints in the top course of plant mix shall be constructed at the center line or lane line. If those locations are not practicable, the joint may be constructed near the center of the lane by paving in echelon or outside of the lane lines, if directed. A joint heater shall be used when directed if the asphalt surface temperature near the joint is less than 60 degrees F.

A transverse joint shall be made in a course if laying of that course is to be discontinued long enough to let the mixture become cold. The transverse joint may be formed or cut but shall result in a vertical face the full depth of the course. Material that is cut away to make the vertical face shall be removed, the joint face brushed with asphalt and the fresh mixture compacted against the joint face when paving is resumed.

The end of a course that is temporarily subjected to traffic shall be beveled at the approximate ratio of 20 horizontal to 1 vertical. When paving of the course resumes, a transverse joint shall be made.

Joints at bridge ends or other rigid structures shall be made by first conditioning and compacting the existing base. The mixture shall be placed slightly higher than the structure. Compaction shall be in transverse direction as well as longitudinal and as directed.

(G) Compaction. Immediately after the bituminous mixture has been spread and struck off and the surface irregularities adjusted, it shall be thoroughly and uniformly compacted by rolling. Rolling shall be continued while the mixture is in a workable condition and shall provide at least 95 percent of the density of a test specimen made from the mix used at the job site. Test specimens will be prepared in the field and tested for density according to Montana Test Method MT-306. Field density determinations will be performed with a nuclear field density device in accordance with Montana Test Method MT-212.

Breakdown rolling shall be done as soon as the mixture will support the roller without undue displacement, transverse cracking or hairline checking and shall be completed by the time the spread bituminous mixture reaches a minimum temperature of 175°F.

Finish rolling shall begin as soon as possible after the breakdown rolling and continue until all roller marks are eliminated or until the engineer determines that sufficient rolling has been done. Finish rolling shall be completed the same day the mixture is placed.

The number, weight and type of rollers furnished shall be sufficient to obtain the required compaction and finishing without undue displacement, cracking or shoving. Pneumatic tires shall be inflated to obtain the contact area pressures required in Article 30.09 (C).

Unless otherwise directed, rolling shall begin at the sides and proceed longitudinally parallel to the road centerline, each trip overlapping one-half the roller width. Rollers shall move at a slow, uniform speed with the drive wheel nearest the paver except on steep grades.

When the pavement is placed by machines in echelon or abutted against a previously placed lane, the longitudinal joint shall be rolled first, followed by the regular rolling procedure. On super elevated curves, the rolling shall begin at the low side and progress to the high side by overlapping of longitudinal trips parallel to the centerline.

Any displacement occurring as a result of the reversing of the direction of a roller, or from other causes, shall be corrected at once before final compaction. Care should be exercised in rolling not to displace the line and grade of the edges of the bituminous mixture.

To prevent adhesion of the mixture to the rollers, the wheel shall be kept properly moistened with water or water mixed with very small quantities of detergent or other approved material. Excess liquid will not be permitted.

Along curbs, forms, headers, walls, and other places not accessible to the rollers, the mixture shall be thoroughly compacted in accordance with Article 30.12 (E).

Any mixture that becomes loose and broken, mixed with dirt, or is in any way defective shall be removed and replaced with fresh hot mixture, which shall be compacted to conform with the surrounding area. Any area showing an excess or deficiency of bituminous material shall be removed and replaced.

(H) Control Strip. The control strip method for determining density requirements shall be used when the contractor cannot conform with the 95 percent density requirement. The control strip method shall not be utilized however until the contractor has satisfactorily demonstrated that other remedies will not achieve the 95 percent density requirement. These remedies shall include but not be limited to the following:

1. Increase compaction effort by change in size, type, number, pattern and operation of rollers.
2. Mix gradation change.
3. Mix temperature change.
4. Mix asphalt content.

5. Mix moisture change.

Each control strip shall be constructed with approved bituminous mixture and shall remain in place as a section of the completed work. Each control strip shall be one paver width wide and at least one hundred feet long and shall be of the depth specified for each lift.

Equipment proposed for use in the compaction of control strips shall be approved by the engineer prior to use. All rollers shall be self-propelled, in good condition, and capable of reversing without back lash. Rollers shall be operated at speeds slow enough to minimize displacement of the bituminous mixture. The use of equipment which results in excessive crushing of the aggregates will not be permitted. Finish rolling shall begin as soon as possible after the initial breakdown rolling. All rollers shall conform to sub-section 13.10.

Compaction of the control strip shall commence as soon as possible after placement of the bituminous mixture and be continuous and uniform over the entire control strip.

During the rolling process the density of the control strip will be determined by the engineer with a portable nuclear test device. When the engineer determines that the increase in density is less than one pound per cubic foot per coverage, the rolling shall be stopped. The mean density of the control strip will be determined from five tests at randomly selected test sites within the control strip.

One control strip shall be constructed at the beginning of work on each roadway and each lift of each course. An additional control strip shall be constructed when a change is made in the type or source of material or whenever a significant change occurs in the composition of the material from the same source.

A new control strip may also be ordered by the engineer or requested by the contractor when:

- (1) A change in the material or job-mix formula is made.
- (2) Ten days of production have been accepted without construction of a new control strip.
- (3) There is reason to believe that a control strip density is not representative of the material being placed.

The required compaction of the remainder of the course, shall be governed by the mean density of the control strip until a new control strip has been constructed. The remainder of the course shall be divided into sections approximately 2,000 feet long for the purpose of defining areas represented by each series of density test sections. The same procedure

and rolling equipment used on the control strip shall be used on the test sections.

The density of each test section will be evaluated based upon the results of five tests with a portable nuclear test device performed at randomly selected sites within the test section. The mean density obtained for the five tests in each test section shall be at least 98 percent of the mean density obtained in the approved control strip. In addition, each individual test value obtained within a test section shall be at least 96 percent of the mean density of the control strip.

If the mean density of the test section does not conform to the requirements stated herein above, or if an individual test value does not meet the requirements stated herein above, the contractor shall continue his compactive effort until the required density is obtained.

Acceptance density testing shall be accomplished while the bituminous mixture is hot enough to permit further densification if such is shown to be necessary.

(H) Pavement Repair. If repairs are made by cutting out the pavement, the sides and bottom of the hole shall be cleaned and brushed with an approved bituminous material. Fresh mixture shall then be placed into the hole, compacted and leveled to meet the required surface smoothness.

30.13 SURFACE TOLERANCES. The finished surface will be inspected for conformance to specified grade and typical section. Testing will be with a ten-foot straight edge paralleling the center of the roadway. The variation of the surface from the testing edge of the straight edge between any contact points with the surface shall at no point exceed three -sixteenths inch on the wearing course of pavements.

30.14 METHOD OF MEASUREMENT.

(A) The pay weight will include the bituminous material and any mineral filler contained in the mixture. The plant mix surfacing materials will be measured by the ton, on approved scales, after complete mixing of all ingredients. In lieu of platform scales, batch weights in automated batch plants are permitted as a method of measurement in which case the cumulative weight of all batches will be used for payment.

Batch weight tickets shall be issued for each load when the batch plant is equipped with an automatic printer system as described in Article 30.04 (11). For automated batch plants not equipped with automatic printing systems a batch counter shall be utilized. The Engineer will record the

batch counter reading at the beginning and finish of each days production.

The recorded weight shall be accurate to 0.5 percent of the true weight. The Engineer may require random loads to be checked on approved platform scales.

(B) Bituminous material will be measured in accordance with Article M-120.05.

(C) Mineral filler will be measured by the ton in accordance with Article M-340.07.

(D) Anti-stripping additive shall be measured by the unit to the nearest 0.01 of a unit.

One unit is one percent by weight for each ton of bituminous material. When the percentage of additive blended into the bituminous material is increased or decreased the number of units for payment shall proportionately increase or decrease. The percentage of additive, brand, grade or type of additive must be shown on the certificate of compliance. See Article M-120.03.

(E) Other contract items will be measured in accordance with the requirements of the respective specifications.

30.15 BASIS OF PAYMENT.

(A) Plant mixed surfacing material, used in the completed and accepted work, will be paid for at the contract unit price per ton. This price and payment, except as may be otherwise specified, will be full compensation for the work.

The compaction of the specified course and the cost of constructing density control strips will not be measured for payment.

(B) Bituminous material used in the accepted mixture, for tack or prime coat or in painting joints, gutters, headers, manholes, curbs, and the like, will be paid for at the contract unit price, in accordance with Article M-120.06, and shall include all operations necessary to complete the work.

(C) Existing surface preparation, unless otherwise specified, will not be paid for separately but will be included in payment made for the other items of the contract and shall include all operations necessary to complete the work.

(D) Mineral filler will be paid for at the unit price per ton except as otherwise specified in accordance with Article M-340.07. Payment will be

full compensation for furnishing, hauling and incorporating the mineral filler into the bituminous mixture.

If the contract specified Hydrated Lime as the Mineral Filler, the contract unit price shall include all costs associated with furnishing, hauling and incorporating hydrated lime into the bituminous mixture.

If the contract does not specify Hydrated Lime as the Mineral Filler but the engineer decides that the Mineral Filler will be Hydrated Lime, then the contract unit price for Mineral Filler will be waived.

The contractor will be paid the invoiced price for Hydrated Lime, delivered on the project, as supported by certified copies of invoices for such material plus an additional four dollars per invoiced ton. The additional four dollars per invoiced ton shall be full compensation for incorporating the Hydrated Lime in the bituminous mixture.

(E) Anti-stripping additive, used in the accepted mixture, will be paid for at the contract unit price per unit to the nearest 0.01 of a unit, which price and payment shall be full compensation for furnishing, mixing and properly blending with the bituminous material.

SUBSECTION 30.20 — PLANT MIX BITUMINOUS BASE COURSE

30.21 DESCRIPTION. The plant mix bituminous base course shall be composed of a mixture of aggregate, filler if required, and bituminous material mixed in a central plant, spread and compacted, on an approved surface in reasonably close conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the Engineer.

30.22 COMPOSITION OF MIXTURES. At least 15 days before mixing, representative samples of the proposed aggregates will be submitted and analyzed for asphalt content. The percent of asphalt by weight of total mix shall be within the range of 3 1/2 to 6 with a permissible variation of plus or minus 0.5 percent. The upper limit may be raised when absorptive aggregates are used.

30.23 MATERIALS.

(A) **Bituminous Material.** Bituminous material shall meet the requirements of Section M-120 for the type and grade specified in the contract. The engineer may change the grade one step at no change in unit price.

Bituminous tack and prime material, if required, shall meet the applicable requirements of Section 31.

(B) Aggregate. Aggregate production and stockpiling shall meet the applicable requirements of Section 20. The produced aggregate shall meet the provisions of Article M-100.02, and the following requirements:

(1) The material, from which the aggregate is to be produced, shall have a wear factor not to exceed 50 percent at five-hundred revolutions, as determined by Montana Test Method MT-209.

(2) The material, from which the aggregate is to be produced, shall not have a swell of more than 15 percent in eight days and shall show no cracking or disintegration when tested for volume swell as determined by Montana Test Method MT-305.

(3) The portion of the total aggregate passing the No. 40 sieve shall have a plasticity index of not more than six, as determined by MT-208.

(4) Dust Ratio. The portion passing the No. 200 sieve shall not be greater than two-thirds of the portion passing the No. 40 sieve.

(5) Aggregate for Plant Mix Bituminous Base Course shall meet the gradation requirements of TABLE I below, including mineral filler when used.

The point of acceptance for the aggregate will be after drying but before bituminizing.

TABLE I — PLANT MIX BASE COURSE

**Percentage by Weight Passing Square-Mesh Sieves
Montana Test Method MT-405**

SIEVE SIZE	PERCENT PASSING	
	GRADE I	GRADE II
1 1/2 Inch Sieve	100	-----
1 Inch Sieve	90-100	100
No. 4 Sieve	35- 65	35- 65
No. 200 Sieve	3- 10	3- 10

When hydrated lime is introduced into a Plant Mix Base Course, it shall be considered as a chemical additive and shall not be included in the test results for the percentage of material passing all sieves.

30.24 CONSTRUCTION REQUIREMENTS.

(A) General. Plant Mix Bituminous Base shall be constructed in layers not exceeding 0.35 ft. in thickness. However, any layer which is to be a

riding course shall not exceed 0.25 ft. in thickness. A tack coat shall be used between layers when the base course is constructed in more than one layer.

(B) Equipment. The¹ central mixing plant shall be a batch, continuous flow or dryer drum meeting the requirements of Article 30.04 (B) and the requirements of Article 30.06, 30.07, or 30.08, whichever is applicable, except Intermediate screening or bin storage will not be required.

Motor graders, rollers, pavers and trucks shall meet the applicable provisions of Article 30.09. Pavers are required to have automatic grade controls for all lifts.

(C) Preparation of Aggregates. Aggregates shall be prepared in accordance with Article 30.10 except that Dried and heated aggregates may be transferred from the dryer directly to the mixing unit.

If the gradation of aggregate materials cannot be continuously maintained within the specified gradation limits, aggregate gradation controls shall be used.

(D) Preparation of Bituminous Mixtures. Bituminous mixtures shall be prepared in accordance with the requirements of Article 30.10.

(E) Weather and Roadway Limitations shall be as specified in Article 30.04 (A).

30.25 PLACING AND COMPACTING. The plant mix base material shall be laid upon an approved surface, spread and struck off to the grade and elevation established. Bituminous pavers or other approved laydown equipment shall distribute the mixture over the entire width or over such partial width as may be practicable.

The bituminous mixture shall be thoroughly and uniformly compacted by rolling immediately after it is spread and struck off. In no case shall less than two rollers be furnished. The number of rollers shall be increased, when directed, to keep pace with production. A steel wheel roller shall also be used, if directed. Rolling shall be continued while the mixture is in a workable condition until all roller marks are eliminated and a density of at least 95 percent of a test specimen is obtained. The test specimen will be prepared in the field in like proportions to the mix being used and tested in accordance with Montana Test Method MT-306.

30.26 SURFACE TOLERANCE. The finished surface shall be free of defects or depressions exceeding three-eighths inch, as measured by a ten foot straightedge held parallel to the roadway centerline. All work not meeting surface tolerance requirements shall be corrected as directed.

30.27 METHOD OF MEASUREMENT. Plant Mix Bituminous Base Course will be measured as specified in Article 30.14.

30.28 BASIS OF PAYMENT. The accepted quantities of Plant Mix Bituminous Base Course, measured as specified, will be paid for at the contract unit price for each ton of bituminous base mixture.

Mineral filler and "Existing Surface Preparation", if used, will be paid for as specified in Article 30.15. Bituminous material used in the accepted Plant Mix Bituminous Base Course and prime or tack coat will be paid for in accordance with Article M-120.05 at the contract unit price.

NOTES

SECTION 31

BITUMINOUS PRIME OR TACK COAT

31.01 DESCRIPTION. This work shall consist of preparing and treating an existing surface with bituminous material, and blotter material if required, in substantial conformity with these specifications and the plans.

Prime Coat shall be the application of bituminous material to previously prepared aggregate or soil surface roadway, preparatory to placing surfacing materials. **Asphalt included in the contract for use as prime oil shall be used only when so directed by the engineer.**

The quantity of asphalt included in the contract for use as prime oil is not guaranteed to be used or required. The Department reserves the right to increase, decrease or omit all or any part of the item and no compensation will be allowed by reason thereof.

Tack Coat shall be the application of bituminous material to a previously constructed surface of any type, in preparation of placing bituminous surfacing materials.

31.02 MATERIALS.

Bituminous Material. The type and grade of bituminous material will be specified in the contract or shown on the plans and shall meet the requirements of Section M-120.

The engineer reserves the right to change or substitute the type and grade of bituminous material to be used, depending on seasonal or other conditions. In case of such change or substitution, the basis of payment will be in conformity with Article M-120.03 (G). The grade may be changed one step, by the engineer, at no change in unit price.

31.03 WEATHER LIMITATIONS. Prime Coat shall be applied only to a dry surface, during daylight, when the atmospheric temperature is not less than 50 degrees F. unless otherwise directed. Tack Coat shall not be applied during wet weather, after sunset, or to a wet surface.

Neither Prime nor Tack Coat may be applied when the engineer determines that weather or roadway surface conditions are unfavorable to achievement of satisfactory results.

31.04 EQUIPMENT. Equipment shall meet the requirements of Article

32.03 to the extent required for satisfactory accomplishment of the phase of the work.

31.05 CONSTRUCTION METHODS. Construction shall be performed in accordance with Article 32.04 except as herein modified or supplemented.

The requirement under Article 32.04 (A) that, "the top two inches of the course shall not contain more than three percent of moisture by weight of aggregate," shall not apply.

Amount of bitumen, to be applied and rates of application, shall be as directed by the engineer in accordance with on-the-job determinations of the particular work requirements. Prior to the application of the prime coat upon an aggregate base, if in the opinion of the engineer the surface has become too dry, water shall be applied to the surface at a rate designated by the engineer. Bituminous material shall not be applied when surface or weather conditions would prevent proper construction.

When SS-1 Emulsified Asphalt is called for on the plans, it shall be applied as directed by the engineer and at a rate not to exceed one tenth gallon per square yard. The proportions of water and emulsified asphalt blended for application may vary from one to three parts of water with one part of emulsified asphalt, the exact proportion to be determined during construction by the engineer. The distribution unit shall conform to the requirements specified for "Bituminous Material Pressure Distributor" in Article 32.03 (A) and the SS-1 Emulsified Asphalt shall conform to Section M-120.

The exact quantity may vary and the Department reserves the right to increase or decrease the item and no compensation will be allowed by reason thereof.

Prime coat shall not be applied to any aggregate surface that contains an excessive percentage of moisture, as determined by the engineer.

(A) Blotter Material. The contractor shall spread "blotter material", only when directed, to surfaces covered by bitumen, in areas and within the time designated by the engineer. Spreading shall be done by approved methods.

Compaction of the "blotted" surface shall be done with approved rolling equipment and methods, if compaction is required.

Surplus "blotter material", resulting from any spreading method, shall be swept from the "blotted" surface by power brooming, hand brooming or blowing before placing other bituminous surfacing courses over the "blotted" areas. The surplus material swept from the "blotted" surface

shall be loaded, hauled and disposed of from locations where curbs are encountered such as structures or urban areas. Similar removal and disposal methods may be required in other locations, otherwise surplus material may be swept from the "blotted" surface into the shoulders and inslopes.

The "blotter material" shall meet the requirements in Article M-100.07 of the Standard Specifications and shall be crushed Top Surfacing Type "A" of the size specified in the contract.

The quantity of "blotter material" specified in the contract, is separate from the other quantities of like sized surfacing aggregates and is not guaranteed to be used or required. The Department may increase, decrease or delete any portion of the item but will allow no additional compensation because of such increase, decrease or deletion.

(B) Maintenance of Surface. The contractor shall maintain the prime or tack coat surface intact until it has been covered with subsequent surfacing. All breaks, holes, failures or deterioration or disintegration of the underlying course or courses of surfacing, from any cause, shall be satisfactorily repaired. Costs of such repairing, including any materials will not be paid for directly, but will be considered included in the bid items of the contract, with the exception: That when the engineer determines that it becomes necessary, for the convenience of the traveling public, to apply a bituminous prime coat immediately prior to the expected advent of winter weather, additional materials required to satisfactorily repair the surface due to traffic use during the winter shut down period, will be measured and paid for at the respective contract unit prices. All other cost and work in repairing the surface will not be paid for directly, but will be considered necessary and incidental to the completed work and included in the other contract items.

31.06 TRAFFIC CONTROL AND PROTECTION OF HIGHWAY STRUCTURES. Traffic Control and protection of highway structures shall be performed in accordance with Article 32.05 and special provisions. When so directed by the engineer, not more than one-half of the width of the roadway shall be treated in one application. Care shall be taken that the application of bituminous material at the junctions of spreads is not in excess of the specified amount. Excess bituminous material shall be squeegeed from the surface. Skipped areas or deficiencies shall be corrected. Building paper shall be placed over the end of the previous applications and the joint application shall start on the building paper. Building paper used shall be removed and satisfactorily disposed of.

31.07 METHOD OF MEASUREMENT. Bituminous material will be measured in accordance with Article M-120.04.

Rolling and watering will be measured in accordance with section 13.

Emulsified asphalt will be measured in agreement with Article M-120.04. Additional water required for dilution subsequent to delivery on the project will not be measured for payment.

"Blotter material", used in the completed and accepted work, will be measured by the units specified in the contract, either tons or cubic yards. Measurement will be made in accordance with the applicable provisions of Article 20.07.

31.08 BASIS OF PAYMENT. Bituminous material will be paid for at the contract unit price in accordance with Article M-120.05.

Rolling, watering and other items will be paid for at the contract unit prices in accordance with Section 13 and other pertinent sections.

Emulsified asphalt will be paid for in agreement with Article M-120.05. Additional water, for dilution, which may be added subsequent to delivery on the project will not be paid for separately but will be considered to be a part of and absorbed in the contract unit price for emulsified asphalt.

Payment, for blotter material, will be made in accordance with the applicable provision of Article 20.08.

SECTION 32

BITUMINOUS SURFACE TREATMENT

32.01 DESCRIPTION. Bituminous Surface Treatment shall consist of one or more applications of bituminous material on a properly prepared roadway surface with each application, unless specified otherwise, being covered with aggregate surfacing material in conformity with these requirements and the specifications and plans.

32.02 MATERIAL.

(A) **Bituminous Material.** Material shall be the type and grade stipulated in the contract or shown on the plans and shall meet the requirements of Section M-120.

(B) **Aggregate.** Aggregate for covering the bituminous material shall be the type and grade stipulated in the contract or shown on the plans and shall meet the requirements of Article M-100.

(C) **Bitumen.** Quantities of bitumen and aggregate will be as specified on the plans or as directed by the engineer.

32.03 EQUIPMENT. The contractor shall maintain on the project, throughout the course of this phase of the work, the following listed, previously approved, equipment

(A) **Distributor.** One fully operable bituminous material pressure distributor of at least 1,000 gallon capacity meeting the following requirements: The tank shall be insulated and equipped with internal steam coils or equivalent heating facilities. The distributor shall be fully equipped with a spray bar of the full circulating type at least nine feet in length, so constructed as to permit adjustment for length in increments of one foot for lengths up to sixteen feet and to allow vertical adjustment of nozzles to the desired height above the road surface and conforming to the roadway crown and to permit lateral shifting of the entire spray bar during operation. The spray bars and nozzles shall be constructed so as to prevent clogging of the nozzles during intermittent operation and provide positive and immediate cutoff when distribution of the bitumen ceases, thus preventing dripping of the bitumen from the bar. The nozzles attached to the bar shall be of an approved flat-slotted type. The valves

which control the flow from nozzles shall be of positive acting design to provide a uniform unbroken spread of bitumen on the surface.

The distributor shall be equipped with devices and charts to provide for accurate rapid determination and control of the amount of bitumen being applied per square yard of surface and a tachometer of the fifth-wheel type indicating speeds in feet per minute. The pressure pump shall be powered independently from the propelling motor of the vehicle. This distributor shall be equipped with a pressure pump, pressure gauge, thermometer well, thermometer and an accurately calibrated fluid content gauge. It shall be equipped with pneumatic tires of sufficient number to meet the legal road requirements of the Department and shall be adequately powered to perform the necessary work without assistance from other units. In addition, the distributor spray bar shall be so arranged that its height above the roadway, as set, shall remain constant throughout the application of bituminous material to the surface.

The distributor shall be capable of applying the bituminous material with an allowable variation, from any specified rate, of not to exceed 0.02 gallons per square yard.

(B) Heating Equipment. As necessary for heating bituminous material to the required application temperature.

(C) Rollers. Rolling equipment shall meet the applicable requirements of Article 13.12 (D).

(D) Aggregate Spreader. One self-propelled aggregate spreader of approved design supported by at least four wheels equipped with pneumatic tires on two axles. The aggregate spreader shall be equipped with a means of applying the larger cover coat material to the surface before the smaller cover coat material and with positive controls so the required amount of material will be deposited uniformly over the full width of the bituminous material. Other types of aggregate spreaders may be used provided they accomplish equivalent results and are approved.

(E) Cleaning Equipment. For cleaning roadway surface equipment may consist of, efficient power brooms, blowers, suitable hand brooms and the like.

(F) Water Facilities. For wetting cover aggregate if and as required.

(G) Watering Equipment. Shall meet the requirements of the applicable provisions of Subsection 13.50.

(H) Scales. Shall meet the applicable requirements of Section 20.

32.04 CONSTRUCTION METHODS.

(A) Existing Surface Preparation. Unless surface preparation is included in surfacing items of the contract, the required work shall be performed in accordance with the pertinent provisions of Article 19.22 except as may be herein modified or supplemented.

Attention is directed to the condition that stability and riding quality of the completed bituminous surface treatment is dependent on the careful preparation and smoothness of the aggregate surface to which the treatment is applied. The entire course of surface aggregate to which the bituminous surface treatment is applied shall not be laid down and prepared until such time as weather and other conditions will permit the immediate application of bitumen.

If directed, a light, uniform application of water shall be applied to the roadway surface just prior to application of the bitumen. Equipment shall conform to Subsection 13.50. The top two inches of the course shall not contain more than three percent of moisture by weight of aggregate. If determined necessary by the engineer, as a measure of surface consolidation, a prime coat of bituminous material shall be applied, at the rate directed, prior to the initial application of bituminous surface treatment.

It is the intent of this specification that the contractor shall not place any cover aggregate upon the roadway until such a time that he can complete the paving operations without interruption. If the paving operation cannot be completed, the cover aggregate may be stockpiled at his option.

(B) Sweeping. Immediately prior to the first application of bituminous material, the roadway surface shall be swept clean of all dust, dirt or foreign matter, by means of a power broom, blower or hand brooming as required for satisfactory cleaning of the surface.

(C) First Application of Bitumen. Immediately following the cleaning and wetting of the roadway surface, the first application of bitumen shall be uniformly applied at the temperature and at the rate per square yard, as directed, by means of a pressure distributor of the type described hereinbefore. Bitumen shall not be applied until the atmospheric temperature is at least 65 degrees F. and rising. Extreme care shall be taken in application of the bitumen to secure uniform surface cover and true lines. Weather conditions shall be such that the bitumen will not become chilled before the cover material can be spread and rolled. The first application shall not be applied before May 15 nor later than September 15 without written approval by the engineer. Work shall not be

started without consent of the engineer and shall be promptly terminated in the event of rain, high wind velocity or the occurrence of unfavorable road or weather conditions.

(D) Application of Cover Aggregate. When directed by the engineer, the first application of bitumen may be allowed to remain uncovered for a period of time up to sixty minutes. Spreading of a minimum amount of cover aggregate shall be made on the freshly spread bitumen, when the engineer determines that the maximum depth of downward penetration has been attained and that the consistency of bitumen has become such that the best "keying" results will be obtained. In the case of heavy viscosity types of bituminous materials, the contractor shall not proceed with the application of bitumen until a supply of aggregate sufficient to cover the entire application is immediately available for covering the bitumen in less than five minutes. The bitumen application shall be covered with the specified cover aggregate, at the directed rate per square yard, spread uniformly over the bitumen with a self-propelled mechanical spreader of the type hereinbefore specified. Aggregate spreaders that fail to make a uniform and satisfactory distribution of material must be promptly removed from further use. Special care must be exercised in the spreading of cover aggregate to insure uniformity of cover and security of longitudinal lines.

When directed by the engineer, water shall be applied to stockpiled cover aggregate at least three days prior to spreading on the bituminous material.

When directed by the engineer, brooming, by mechanical or hand methods, shall be employed to provide uniform distribution of the cover aggregate. Particular caution shall be exercised in brooming to avoid displacement or loosening of cover aggregate particles from the bitumen.

Bituminous material shall not be applied in meet line areas where the uncovered bitumen has cooled to the extent that the maximum amount of cover material will not be keyed.

Bitumen shall be applied with care in order that transverse and longitudinal joints or meet lines of successive applications will be smooth and consistent with adjacent completed surfaces.

Longitudinal laps (meet lines) may be from six to ten inches in width, but there shall be no overlap at the end junction of applications. In order to prevent lapping at transverse junctions, the distributor shall be promptly shut off, and, if necessary to prevent dripping, a drip pan shall be inserted under the nozzles when the application begins to thin. Before continuing application of the bitumen, building paper or metal sheets shall be spread over the treated surface for a sufficient distance back from the joint on the

cover aggregate so that the sprayers are operating at full force, and the distributor has attained the predetermined speed upon reaching the surface to which application is to be made. The bitumen application shall be stopped or shut off on paper or metal sheets. Any paper used for covering joints shall be removed and destroyed.

All transverse joints shall be covered with aggregate and broomed back before the next longitudinal application of bitumen is made. Trucks hauling covering material to the spreader units, or traffic, shall not be permitted to cross over or drive on any uncovered bituminous material including "meet" lines. When operating over freshly spread cover aggregate, the speed of vehicular traffic shall be so regulated that loosening and displacement of cover aggregate shall not occur. Drivers failing to observe these requirements shall be promptly dismissed from the work. When it is necessary to cover "meet" lines to permit trucks or traffic to cross over, such cover aggregate shall be neatly broomed back exposing the full width of the "meet line" before the abutting application of bitumen is made.

There shall only be permitted a minimum number of "meet lines", compatible with the width of the roadway surface. Permission may be granted by the engineer to make full road surface width application of bitumen and cover aggregate, to be performed in a single continuous operation so coordinated that the movement of public traffic will not suffer greater inconvenience than that resulting from strip or half roadway width methods.

(E) Rolling. Rolling of cover aggregate shall commence immediately upon spreading and shall be prosecuted with such diligence that all freshly spread material shall be promptly rolled without delays. Rolling shall be accomplished with pneumatic tired rollers capable of a ground contact pressure of not less than 50 psi nor more than 95 psi. Rolling shall proceed in a longitudinal direction beginning at the outer edges of the treatment and working toward the center, each trip overlapping the prior trip by about half the width of the roller. The first rolling of the aggregate must be completed within one-half hour after it has been spread. All rollers shall be self-propelled and two rollers must be used for each aggregate spreader used. The rolling shall be continued only until a smooth thoroughly compacted surface has been obtained. The speed and reversal of direction of movement of rollers shall be so regulated as to avoid displacement or loosening of cover material.

(F) Curing Time After First Application. After rolling is completed and the surface is smooth and free of ruts and ridges, the surface may be

opened to traffic subject to traffic protection requirements of the special provisions.

The surface shall be allowed to cure for a minimum period of five days and longer, if necessary, as determined by the engineer, for the surface to become satisfactorily cured for placement of the succeeding course. The second application shall not be applied before May 15 nor later than September 15 without written approval by the engineer. Any breaks or holes that develop in the treated surface shall be substantially repaired immediately with bituminous treatment methods or a premixed bituminous aggregate. Any areas showing excessive bitumen shall be covered with aggregate and rolled. Cost of any such repairing required will not be paid for directly but will be included in the other items in the contract.

(G) Cleaning. After the first application of bitumen and cover aggregate has satisfactorily cured and set, as directed by the engineer, and any repairs required have been properly made, all excess cover aggregate, dirt, dust and foreign materials shall be removed from the surface by sweeping with power brooms, hand brooms, blowers or water washing to produce a positively clean surface. Construction of the succeeding course may then proceed on the clean surface in agreement with the construction methods specified for the preceding course.

(H) Completion. Upon completion of the final course, the surface shall be opened to traffic for a period of three days, with the specified period of traffic control in effect. During this period, the surface shall be maintained by brooming and rolling, as directed. Any holes or breaks that may occur shall be satisfactorily repaired by methods hereinbefore specified. Any areas showing excess bitumen shall be covered with aggregate and rolled. Any irregularities influencing the stability and riding quality of the surface shall be corrected in a satisfactory manner. Cost of any such repairing or corrections will not be paid for directly but will be included in the other contract items.

32.05 PROTECTION OF TRAFFIC AND HIGHWAY STRUCTURES.

(A) Traffic Control. Traffic control shall be performed in accordance with Article 04.04 (C) (5) (a).

(B) Structure Protection. The contractor shall provide whatever protective covering may be necessary to protect exposed portions of bridges, culverts, curbs, gutters, guard fences, road signs and other roadside structures from becoming splashed or sprayed with bitumen and he

shall remove from such structures, any bitumen, dirt or other undesirable matter that may come upon them by reason of his operation. Compensation for this protection will be included in the contract unit price for the application of bituminous material.

The contractor shall recondition, at his own expense, any damage done to the Highway or structures due to the operation of his equipment or caused by traffic being forced away from the usual line of travel.

32.06 METHOD OF MEASUREMENT.

(A) **Bituminous Material** including prime required and used in completed and accepted work will be measured by the U.S. Gallon, or by the ton, as stipulated in the contract and in accordance with Section M-120.

(B) **Cover Aggregate** used in the completed and accepted work will be measured by the ton on scales furnished by the contractor, or by the cubic yard measured in the vehicle at point of delivery on the roadway, as stipulated in the contract and in accordance with applicable provisions of Article 20.07.

(C) **Rolling** will be measured as provided for in Article 13.14.

(D) **Other Items** specified in the contract will be measured as stipulated in the contract.

32.07 BASIS OF PAYMENT. Application of any bituminous material, cover aggregate, rolling, watering and other items specified in the contract, will be paid for at the contract unit prices, which prices and payment will be full compensation for furnishing all material, for delivering, preparing, handling and placing all materials and for all other charges; for maintenance of the completed surface until acceptance and for all other operations necessary to complete the work.

On projects in which the construction of the base and bituminous surface treatment is included in one contract, "Existing Surface Preparation" will not be paid for as a separate item, but will be considered as incidental to the base construction.

On projects in which bituminous surface treatment is a separate contract, "Existing Surface Preparation" shall be performed in accordance with Subsection 19.20 and unless otherwise specified, the work required for existing surface preparation will not be paid for directly but will be considered incidental to the payment for other items in the contract.

Watering of cover aggregate will not be paid for directly but will be included in the contract unit price for other items.

For Payment of Bituminous Material — See Section M-120.

For Payment of Cover Aggregate — See Section 20.

For Payment of Rolling — See Section 13.

For Payment of Traffic Control — See special provisions.

Unless otherwise provided, traffic control will not be paid for directly, but will be considered incidental and necessary to the performance of, and included in the payment for the other items of the contract and will include all labor, equipment, tools, lights, signs and all incidentals necessary to complete the work.

SECTION 33

ROAD MIX BITUMINOUS PAVEMENT

33.01 DESCRIPTION. Road Mix Bituminous Surfacing shall consist of aggregate and bituminous material, constructed on the roadway by mechanically mixing and processing these materials and spreading and compacting the resulting completed mixture in agreement with the plans, specifications and the following requirements.

33.02 MATERIAL.

(A) **Bituminous Material** shall be the type and grade stipulated in the contract or shown on the plans and shall meet the applicable requirements of Section M-120.

(B) **Aggregate** to be bituminized shall be all new aggregate, a blend of new aggregate and material obtained from the existing roadway surface, or material obtained only from the existing surface as stated in the contract or plans, new aggregate shall be of the type and grading stipulated which meets the requirements of Section M-100.

33.03 ORGANIZATION. On projects five miles or more in length, the contractor shall be capable of completing at least one-half mile of continuous road mixed surface each day. On projects less than five miles in length, he shall complete the road mix construction in ten working days or less. The contractor shall not open up more than two miles at one operation and at no time shall there be more than three miles under actual bituminous construction. When the project is used by traffic, the rates of progress on the various phases shall be such that only a minimum length of work shall be under construction at one time. Sufficient mixing units shall be maintained on the Project to insure compliance with the required rate of construction progress.

33.04 EQUIPMENT.

(A) **Bituminous Distributor.** The contractor will be required, regardless of project length or type of mixing equipment being used to maintain on the project, a bituminous distributor meeting the requirements of Article 32.03 (A).

(B) **Motor Graders.** Shall meet the requirements of Article 16.02 (B).

(C) Road Plants and Machines. All traveling road mixing plants and machines shall meet the approval of the engineer. Such plants or machines must be equipped with positive measuring devices, to be set as directed and not varied except by his order, for the accurate volume or weight measuring and proportioning of the bitumen and aggregate. Aggregate pickup devices shall be capable of taking up all loose material, leaving the base surface clear and undamaged. Mixing machines which do not pick up the aggregate also may be used, if approved. Auxiliary mixing machines which mix the material on the roadway, but are not equipped with a bitumen proportioning device, also may be used. If the windrow is too large for the machine to handle properly, it may be divided into two or more windrows of workable and equal size.

Use of a traveling plant or mixing machine anticipates the auxiliary use of blade graders to properly aerate the materials, complete the mixing operation and perform "laydown" of the mixture. Irrespective of the type of road mixing plant or machine used, the contractor shall maintain on the project not less than two motor graders of the type specified.

Motive equipment shall be adequately powered to prevent damage, to the roadway surface upon which it is working, caused by slippage or spinning of the traction contact areas.

(D) Stationary Plants. If approved, the mixing of new aggregate and bituminous material in a stationary plant is permitted. In this case mixing and aeration of the material, if not completed in the plant, shall be completed on the roadway as required under these specifications. The contractor may be permitted to accomplish mixing, spreading and compacting of the materials as specified in Section 30. If stationary plant methods are used, no compensation other than price adjustment for change of type or grade of bituminous material will be allowed, except that the grade of bituminous material, may be changed one step, by the engineer at no change in price.

(E) Rollers. Rollers shall conform to Article 13.12.

33.05 CONSTRUCTION METHODS.

(A) Limitations and Conditions.

(1) Weather, Season and Time. The operations of bitumen application, machine or blade mixing, aeration, spreading or compacting shall not be done prior to May 15th, nor continued later than September 15th, without written approval. Such operations shall not be done when the temperature, weather and road conditions are such that the specified

results cannot be obtained. No work shall be accomplished except in daylight.

(2) Stockpiling. The contractor shall place no aggregate, upon the roadway until such time that he can complete the mixing operation without interruption. If the contractor elects to produce the new aggregate at such time that the mixing operation cannot be completed, the aggregate may be stockpiled for later use and the costs and all incidentals involved in the stockpile operations shall be at no expense to the Department. Stockpiling of aggregates shall be done in accordance with the provisions of Article 26.04.

(3) Moisture Content. Should the moisture content of the aggregate exceed three percent by weight, it shall be dried before applying the bitumen if other than emulsified asphalt.

When emulsified asphalt is called for on the plans. The limiting moisture content of the aggregate will be specified in the special provisions or as directed.

In the event of rain during the application of bitumen, or the mixing operation, the material shall be windrowed promptly. If rain occurs and the treated or untreated material is windrowed on the roadway, the contractor shall immediately drain all water puddles. The treated material and the base shall be allowed to dry before the resumption of work, except such mixing as will facilitate drying. In no case shall the bituminized material be "laid" while the material or the roadbed is damp or wet. The engineer will be sole judge as to when the roadbed has dried sufficiently for work to be resumed. In no case shall the moisture content in the upper six inches of the base be more than 3½ percent when the mixture is "laid."

(B) Control of Traffic and Protection of Highway Structures. Control of Traffic shall be performed in accordance with Article 04.04(C)(5)(a). Protection of Highway Structures shall conform to Article 32.05.

Work will be considered in progress whenever the contractor's equipment is on the roadway, regardless whether or not it is in motion, or when material has not been windrowed in a safe manner. At night, or at other times when active work is not in progress, all material shall be left in a uniform windrow, placed as directed, in order to leave the roadway in the safest possible condition for the use of the public.

The treated or untreated gravel windrow shall be signed and delineated according to the requirements of Standard Drawing No. 208. When active

work operations are not in progress and public traffic is involved, all equipment shall be removed from the roadway and parked at a safe distance from the traveled way.

(C) Prime or Tack Coat. Application of prime or tack coat, when designated on the plans and contract, or directed, shall be accomplished in accordance with Section 31.

(D) Aggregate.

(1) Where aggregate is to be obtained in whole or in part, from the existing roadway, the surface shall be scarified to a depth which will produce the quantity of loose material required for the compacted thickness of the bituminous surfacing shown on the plans. Extreme care shall be exercised to avoid loosening of the base surface or scarifying below the depth necessary to produce the required amount of material. All clods shall be broken and the loose material bladed into a windrow. The base surface shall be shaped and compacted to conform to the typical section. When new material is blended with material obtained from the existing roadway, the amount of new material to be added will be designated on the plans or by the engineer. Blending of the old and new material shall be complete, in all respects, before the application of bitumen.

(2) When new aggregate is to be used, the existing roadway surface shall be shaped and compacted to the design sections shown on the plans and the prime coat applied, when directed, prior to placing the new aggregate. The new aggregate for the bituminous surface course shall be placed in a uniform windrow on one side of the roadway. After the material, either new or from the existing roadway, is windrowed at one side of the roadway, the windrow shall be equalized in size throughout its entire length by means of graders or mechanical equalizing devices. When necessary to secure uniformity of the windrow, material shall be hauled from sections where there is an excess to deficient sections.

(E) Bitumen Application. Bituminous material shall be applied at the rates, temperature, and in the manner directed. All aggregate shall have received uniform amounts of bitumen when the application process is completed. When applied with a distributor, or mixing machines equipped with applicators, the windrowed aggregate shall be spread by laying in successive layers not less than eight feet wide with each preceding layer being applied, full width, with a uniform amount of bitumen. Not less than three layers of aggregate and application of bitumen shall be made.

(F) Processing. After the last application of bitumen and partial mixing the entire mass of surfacing material shall be moved by blade graders into

a windrow. The windrow shall then be moved from side to side of the roadway with a revolving motion until all particles of aggregate are coated with bitumen and the whole mass has a uniform color and bitumen content and has been satisfactorily aerated for spreading and compacting the material. At least eight moves of the material across the roadway will be required, under the most favorable conditions of air temperature, material, grading, efficiency of equipment and skillful workmanship. A move shall be understood to consist of the movement of the entire mass from one edge of the proposed roadway section to the other. Under conditions less favorable for effective mixing, as many more moves will be required as is necessary to produce the desired uniformity of mixture. The moving or mixing shall be carried on in such a manner that there will be neither segregation of material nor loss of mineral filler from the mixture.

No mixed material shall be spread, or allowed to remain on the roadway, until the entire mass of material is thoroughly mixed. It then shall be spread and placed in one operation unless, in the judgment of the engineer, it may be expedient to permit a small portion of the mixture to serve as a mixing floor.

Equipment, other than that specified, may be used, with approval of the engineer, if it will produce a completed mixture equal to that which would be produced by the means specified. The engineer reserves the right to order the use of equipment discontinued which, may damage, a section or portion of the roadway or fail to produce a satisfactory end result.

After mixing operations are completed the mixture shall be examined to determine whether the proper proportion of bitumen has been used. If the proportion of bitumen is excessive, additional uncoated material shall be hauled onto the moist section, if directed, which shall be thoroughly mixed with the original mass by blading. If more bitumen is required a portion of the mixed material shall be spread upon one side of the roadway, the required additional bitumen distributed thereon, and the mixing resumed until uniformity of mixture is secured.

Oversize material which may enter the mixture, regardless of its origin, shall be removed from the roadway, at the contractor's expense, during the progress of the mixing.

Costs resulting from the required addition of bituminous material or untreated surfacing material to correct the uniformity of the mix, or additional material or work required due to the entrance of moisture or for other reason prior to the completion of the final rolling of the surface, such as widening of the bituminous surface course over intermittent sections for turnouts, traffic lanes and the like, not shown on the plans, shall be

considered incidental to the unit price of contract items and no additional compensation for such work will be allowed.

(G) Spreading and Compacting. After a satisfactory mixture has been obtained, it shall be spread, by a pneumatic-tired motor grader of the prescribed type, to the specified thickness. Rolling shall be carried on, throughout the lay-down operation, with the pneumatic-tired roller commencing with initial blade layout of the bituminous mixture and continuing until the mat is uniformly and thoroughly compacted and all roller marks are eliminated. Rolling shall proceed in a longitudinal direction, beginning at the outer edges and working toward the center or beginning on the low side, on superelevated sections, and working upward. Each trip shall overlap the prior trip by about one-half the width of the rear roller. The pneumatic-tired roller shall be self-propelled and the pneumatic tires shall exert a pressure on the mat of not less than 60 pounds per square inch.

Final rolling shall be done with the metal-wheeled roller. Roller operating speeds may be between three and eight miles per hour but shall not be of such speed as to cause displacement of material. Any displacement shall be corrected immediately. The use of kerosene or diesel fuel to prevent pick-up on the finishing roller will not be allowed.

Defects, such as raveling, low centers, lack of uniformity or other imperfections caused by faulty workmanship shall be corrected to the satisfaction of the engineer. New work shall not be opened up until such defects have been remedied. However, after the bitumen has been mixed with the aggregate and has been spread and finally compacted in compliance with the specifications, then any additional materials and work, where tear-up and reprocessing are required, will be paid for on a force account basis. (See Article 09.04).

This provision shall not cover failures which result from the effects of rain during the spreading or rolling operation or failures which may be patched or repaired by hand methods, but shall apply to those sections of the surface which necessitates tearing up with motorized equipment, adding bituminous material or aggregate, remixing, relaying and compacting.

The finished surface shall be free of ruts, defects and depressions exceeding three-eighths inch, as measured with a ten foot straightedge, paralleling the center of the roadway and shall have an entirely smooth riding quality. Variations shall be corrected by scarifying and relaying the mixture at the contractor's expense.

(H) **Seal Coat.** Seal coat, when specified, shall be accomplished according to Section 34.

33.06 METHOD OF MEASUREMENT.

(A) Bituminous material will be measured in accordance with Article M-120.04.

(B) New or additional aggregate required for the bituminous surfacing course and the shoulders will be measured in accordance with Article 20.07.

(C) Processing of all bituminous surfacing materials in the completed and accepted work will be measured by the mile along the centerline of the roadway, or by the square yard, as stipulated in the contract.

(D) Rolling and other contract items will be measured in accordance with the requirements of the respective specifications.

33.07 BASIS OF PAYMENT.

(A) Bituminous material will be paid for at the contract unit price in accordance with Article M-120.05.

When emulsified asphalt is called for, the additional water required during mixing as determined by the engineer shall be included in the unit price for emulsified asphalt.

(B) New or additional surfacing aggregate required to construct the bituminous surface course of the shoulders will be paid for at the contract unit price in accordance with the respective requirements of Article 20.08.

When stationary plants are used for mixing as provided in Article 33.04 (D) the weight of bituminous materials and mixing water will be deducted from weight of the total mix for payment.

(C) Aggregate obtained from the roadway will not be paid for directly but shall be considered incidental and necessary to the performance of and payment for the other items of the contract, and shall include all operations necessary to complete the work.

(D) Processing of the bituminous surfacing materials will be paid for at the contract unit price per mile or per square yard, which price and payment will constitute full compensation for the work.

(E) Rolling and other items will be paid for at the contract unit prices in accordance with the requirements of the respective specifications.

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SECTION 34

SEAL COAT

34.01 DESCRIPTION. This work shall consist of an application of bituminous material followed by an application of cover coat material in accordance with these specifications and in substantial conformity with the lines shown on the plans or established by the engineer.

34.02 MATERIAL.

(A) **Bituminous Material** of the kind and grade stipulated in the contract or shown on the plans shall meet the requirements of Section M-120. It is understood that the variables of natural conditions and materials, which are not possible to predetermine, may require adjustments of the application rate of bitumen during the course of the work.

(B) **Cover Aggregate**, of the kind and grade stipulated in the contract or called for on the plans, shall meet the requirements of Article M-100.10. It may be produced under the contract for seal coat or it may be obtained from stockpiles produced under a previous contract, as stipulated in the contract or shown on the plans. It is understood that the variables impossible to predetermine, encountered in performing this work, may require adjustments in the application rate of cover aggregate during work performance.

(C) **Quantities** of bitumen and aggregate will be as specified in the plans or as directed.

34.03 EQUIPMENT. The following equipment will be required:

(A) Equipment for heating and applying bituminous material meeting the requirements of Article 32.03 (A) and (B).

(B) An approved rotary power broom.

(C) A sufficient number of pneumatic-tired rollers, adequate for the work intended and meeting the requirements of Article 13.12(D).

(D) An aggregate spreader, which shall meet the requirements of Article 32.03 (D).

34.04 CONSTRUCTION METHODS.

(A) General. Seal coat operations shall not be performed prior to May 15th, nor later than September 15th, unless authorized in writing.

No bituminous material shall be applied when the roadway surface is damp or wet, or when the temperature of the oil mat to which the material is being applied, is less than 65 degrees F., and rising, or weather conditions are such that the bitumen will become chilled before the cover material can be spread and rolled. Work shall not be started without consent of the engineer and shall be promptly terminated in the event of unfavorable road or weather conditions.

Seal coat shall not be placed on newly constructed or reconditioned surfaces in less than ten days after such surface has been constructed unless directed otherwise.

When directed, the cover aggregate shall be wetted by watering at least three days prior to spreading it upon the bituminous material.

(B) Sweeping. Directly in advance of the first application of bituminous material, the roadway surface shall be swept clean of all dust, dirt, or foreign matter, by means of a power broom, blower or hand brooming, when required for satisfactory cleaning of the surface. Water washing may be required to remove agglomerated clay, shale or other material that resists removal by mechanical or hand methods.

Such cleaning will not be measured nor paid for directly but shall be considered incidental to the other items of the contract.

(C) Application of Bitumen. Immediately following the cleaning, the first application of bitumen shall be uniformly applied, at the application temperature and at a rate per square yard as directed, by means of a pressure distributor of the type described. Extreme care shall be taken in application of the bitumen to secure uniform surface cover and true lines.

If the surface texture on which the seal coat is being constructed is such as to permit rapid absorption, the engineer may direct a preliminary application at a rate of approximately one-tenth gallon per square yard of the type bitumen as specified. Such application will be measured and paid for as provided in the applicable provisions of Article 32.06 and 32.07.

(D) Application of Cover Aggregate. The contractor shall not proceed with the application of bitumen until a supply of aggregate sufficient to cover the entire application is available for covering the bitumen immediately. Spreading of cover material shall be made promptly on the freshly spread bitumen, when the engineer determines that its consistency has become such that the best "keying" results will be obtained.

The bitumen application shall be promptly covered with the specified cover material, at the rate directed.

The cover material shall be spread uniformly over the bitumen with a self-propelled or truck mounted mechanical spreader. The rate of application of the spreader shall be controlled independent of its motive power. Aggregate spreaders that fail to make a uniform and satisfactory distribution of material shall be promptly removed from further use. Special care shall be exercised in spreading cover material to secure uniformity of application and longitudinal lines.

Brooming by mechanical or hand methods, if directed, shall be employed to insure uniform distribution of the cover material. When brooming is resorted to, particular caution must be exercised to avoid displacement or loosening of particles of cover material from the bitumen.

Bituminous material application shall not be made to such a distance that uncovered bitumen in "meet line" areas will become chilled to such extent during the time interval, that it will not successfully "key" the maximum amount of cover aggregate. Bitumen must be applied in such manner and with such care that transverse and longitudinal joints or "meets" of successive applications will not result in ridges or depressions and will be smooth, consistent with the adjacent surface of the completed treatment.

Longitudinal laps (meet lines) may be from six to ten inches in width, but there shall be no overlap at the end junction of applications. To prevent lapping at transverse junctions, the distributor shall be promptly shut off and, if necessary to prevent dripping, a drip pan shall be inserted under the nozzles when the application begins to thin. Before continuing application of the bitumen, building paper or metal sheets shall be spread over the treated surface for sufficient distance back from the joint on the cover aggregate so that the sprayers are operating at full force upon reaching the surface to which application is to be made. The bitumen application shall be stopped or shut-off on paper or metal sheets. Paper used for covering joints shall be removed and destroyed.

All transverse joints shall be covered with aggregate and broomed back before the next longitudinal application of bitumen is made. When it is necessary to cover "meet lines" to permit trucks or traffic to cross over, such cover aggregate shall be neatly broomed back exposing the full width of the "meet line" before the abutting application of bitumen is made.

There shall only be permitted a minimum number of "meet lines," compatible with the width of the roadway surface. Permission may be granted to make full road surface width application of bitumen and cover aggregate, to be performed in a single continuous operation, so

coordinated that the movement of public traffic will not suffer greater inconvenience than that resulting from strip or half roadway width methods.

(E) Rolling. Rolling of cover aggregate shall be in accordance with the requirements of Article 32.04 (E) with the exception that in some instances one roller may be adequate.

The use of equipment which results in excessive crushing of the aggregate will not be permitted.

(F) Opening to Traffic. After the cover aggregate course has been applied, and it is desirable to perpetuate traffic, the surface shall be opened to controlled traffic and maintained for a period, as directed, of not to exceed 48 hours. During this period the specific traffic control as directed in conformity with Section 04.04, shall be in effect and the surface shall be maintained by brooming and rolling as directed.

Holes or breaks that may occur shall be satisfactorily repaired. Areas showing excess bitumen shall be covered with aggregate and rolled. Irregularities influencing the stability and riding quality of the surface shall be corrected in satisfactory manner. Cost of such repairing or corrections shall not be paid for directly but shall be included in the other contract items.

Trucks hauling cover material to the spreader units, or traffic, shall not be permitted under any circumstances to cross over or to drive on any uncovered bituminous material. When operating over freshly spread cover material, the speed of vehicular traffic shall be so regulated that loosening and displacement of cover material shall not occur. Contractor's personnel failing to observe this requirement will be promptly removed from the work.

(G) Stockpiling Aggregates. Stockpiling of aggregates shall be done in accordance with the provisions of Article 26.04.

34.05 PROTECTION OF TRAFFIC AND HIGHWAY STRUCTURES.

Protection of traffic and highway structures shall meet the requirements of Article 32.05.

34.06 METHOD OF MEASUREMENT.

(A) Bituminous material used in the completed and accepted work will be measured by the U.S. Gallon, or by the ton, as stipulated in the contract and in accordance with Section M-120.

(B) Cover material used in the completed and accepted work will be

measured by the ton on scales furnished by the contractor, or by the cubic yard, measured in the vehicle at point of delivery on the roadway, as stipulated in the contract and in agreement with Article 20.07.

(C) Rolling will be measured as provided for in Article 13.14.

(D) Traffic Protection will be measured in conformity with the special provisions.

34.07 BASIS OF PAYMENT. Accepted quantities of bituminous material, cover aggregate, rolling and traffic protection will be paid for at the respective contract unit prices. These prices and payments will be full compensation for furnishing all materials, labor, equipment and incidentals necessary to complete the work. Furnishing water and wetting cover material, when directed, shall be accomplished by the contractor at no additional cost to the Department.

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SECTION 39

PORTLAND CEMENT CONCRETE PAVEMENT

39.01 DESCRIPTION. Portland Cement Concrete Pavement shall consist of a single course of air-entrained Portland cement concrete, with or without reinforcement, constructed on a foundation course or on a prepared base in accordance with these specifications and in reasonable conformity with the lines, grades, thickness and cross sections shown on the plans or as directed.

39.02 MATERIAL

(A) **Concrete.** Concrete shall be composed of Portland cement, fine aggregate, coarse aggregate, an air-entraining agent and water, and shall conform to the requirements for class "AP" concrete, in conformity with Section 40, unless specified otherwise on the proposal form and as may be modified by the special provisions.

(B) **Cement.** Cement shall be Portland Cement meeting the requirements of AASHTO M-85 Type II and applicable provisions of Article 40.04.

(C) **Air-Entraining Admixtures.** Air-entraining admixtures shall be in accordance with Section 40 and as may be modified. The air content shall be five percent, plus or minus one percentage point, as determined by Montana test method M.T. 102.

(D) **Fine Aggregates.** The fine aggregate shall conform to Article M-100.01 (A).

(E) **Coarse Aggregates.** The coarse aggregate shall conform to Article M-100.01 (B).

(F) **Water.** Water used in concrete shall conform to Article M-340.01.

(G) **Reinforcing Steel.** Steel-wire fabric or steel bar mats, when called for, shall be of the sizes and dimensions and located as shown on the plans. Steel-wire fabric reinforcement shall be furnished in flat sheets. Bar mats and the bars used shall be structural or intermediate grade, as specified. All reinforcing steel shall conform to Article M-290.01.

(H) **Dowel Bars.** The dowel bars shall be plain round bars of

intermediate grade open-hearth steel conforming with ASTM A-615, Grade 40. The dimensions of the bars and their positions in the pavement shall be as shown on the plans or as directed. They shall be free from burring or other deformation restricting slipping in the concrete. Before delivery to the site of the work, one-half the length of each dowel bar shall be painted with one coat of lead or tar paint.

The sleeves for dowel bars shall be metal of an approved design to cover two inches, plus or minus one-quarter inch, of the dowel, with a closed end, and with a suitable stop to hold the end of the sleeve at least one inch from the end of the dowel bar. Sleeves shall be of such design that they do not collapse during construction.

(I) Tie Bars. Tie bars shall be bars of steel conforming to ASTM A-615, Grade 40. They shall be of an approved deformed type. The length, size and spacing of the bars shall be as shown on the plans or as directed.

Expansion Joint Filler and Joint Sealing Material shall conform to Section M-150.

(L) Subgrade Paper. Vacant.

(M) Foundation Course. When a foundation course is called for, it shall be pit run gravel, shale, scoria, sand, disintegrated granite, crushed gravel, stone and filler, or similar materials from approved sources and shall conform to the pertinent provisions of Sections 20, 21, or 22, whichever is called for in the contract. This item shall be placed and compacted in conformity with the lines, grades and sections shown on the plans. Granular or soil materials adequately stabilized with a cementing agent may also be used as directed.

(N) Shoulder Surfacing Material. Shoulder surfacing material shall be material specified under part (M) above or called for in the special provisions. It shall be placed and compacted in conformity with the lines, grades and sections shown on the plans.

(O) Curing Compound. Curing compound, when used, shall conform to AASHTO M-148, Type 2, white pigmented, liquid membrane-forming compound.

(P) Composition and Proportioning of Materials. The compositions of the concrete and the proportioning of the materials shall conform to Article 40.03.

39.03 EQUIPMENT

(A) Preliminary. Before paving operations are started, the contractor

shall have at the site and on the project, equipment necessary for the proper preparation of subgrade, batching, paving, finishing and curing and tools necessary for performing all parts of the work. The equipment shall be checked for mechanical condition and adjustment and the design, capacity and mechanical condition shall be approved before any paving work is started. During paving operations, the contractor shall maintain equipment in proper working order and adjustment and shall make any needed resetting or readjustment of the equipment, whenever required. If any equipment proves inadequate to obtain the results specified, such equipment shall be made adequate or other equipment shall be substituted which will obtain the specified results.

(B) Water Supply. When necessary for the supply of water for operations described in the specifications, an adequate pipe line, or sufficient tank capacity, shall be provided by the contractor. Any pipe line used shall be fitted with drains at the low points and air relief valves at the high points and with convenient outlets for paving operations.

The concrete pavement in place for five days after placing and the subgrade or foundation course preparation, shall have prior rights to the water supply. If it should develop that there is not sufficient water for all purposes, the concrete mixer shall be shut down until the water needs of the curing and subgrading operations have been cared for.

(C) Batch Plant. The Batching plant shall include bins, weighing hoppers and scales for fine aggregate and each size course aggregate. If bulk cement is used, a bin, hopper and separate scale for cement shall be included. The cement weighing hoppers shall be properly sealed and vented to preclude dusting. The batch plant shall be equipped with a suitable non-resettable batch counter which will correctly indicate the number of batches proportioned.

Bins and Hoppers—Bins with adequate separate compartments for fine aggregate and each size course aggregate shall be provided in the batching plant.

Weighing and Measuring Equipment—On projects requiring more than 300 cubic yards of Portland cement concrete for paving, batching plants shall be equipped to proportion aggregates and cement by weight, by means of automatic and interlocked proportioning devices of approved type.

(D) Mixers. All mixers shall be capable of combining cement, aggregates, water, and admixtures, if any, into a thoroughly mixed and uniform mass. All mixers shall have attached, in a prominent place, a

manufacturer's plate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of the drum or mixing blades. All mixers shall be subject to all or part of the uniformity tests described in ASTM C-94 if there is any evidence of questionable performance.

Mixers at Site or Central Plant Mixers. These mixers shall be equipped with an approved timing device which will automatically lock the discharge device when the drum has been charged and release it at the end of the required mixing period. The lock shall be equipped with a bell or other suitable warning device which will give a clearly audible signal each time the lock is released. In the event of a failure of the locking and timing device, the mixer may be used temporarily provided the mixing time is increased 50 percent and a suitable clock or watch is situated within full view of the mixer operator. Failure to promptly repair or replace a defective timing device shall be cause to discontinue use of the mixer. The mixer shall also be equipped with a positive mechanical means to prevent the addition of aggregates after the drum has been charged and mixing has begun. Suitable equipment for discharging and spreading the concrete on the subgrade without segregation or excessive re-handling shall be provided.

Truck Mixers and Agitators. Truck mixers shall be a closed water-tight revolving drum suitable powered and mounted. The drum shall be fitted with blades capable of thoroughly mixing the concrete and completely discharging it without segregation. The contractor shall make available copies of the design of the mixer showing dimensions and arrangement of blades. Mixers having blades worn down more than three-quarter inch from the new condition as shown in the design shall not be used until the blades are replaced or repaired. The drum shall be clean and free of hardened concrete.

Truck mixers shall have the manufacturer's plate attached showing the rated mixing and agitating capacity and the rated drum speed for mixing and agitating.

Truck mixers shall be equipped with a suitable revolution counter which will register the number of revolutions of the drum. The counter shall be mounted so that it can be easily read from the ground by both the operator and inspector.

Truck mixers shall be equipped with a water metering device to accurately indicate water added to the batch. The truck mixer metering device will not be required where all batch water is added at the plant or other location through an approved metering device.

(E) Transportation Equipment. Fresh concrete shall be transported in agitating type equipment, unless otherwise approved.

Revolving Drum Mixers. Revolving drum mixers shall conform to the requirements of Article 39.03 (D).

Non-Agitating Transportation Equipment. Bodies of non-agitating concrete equipment shall be smooth, mortar tight metal containers capable of discharging the concrete at a satisfactorily controlled rate without segregation. Covers shall be provided when needed to protect the concrete from drying out or from additional moisture.

Transportation Equipment For Dry Batches. Compartments for transporting dry batches shall be of adequate capacity and construction to properly carry the volume required. Partitions separating batches, shall be adequate and effective in preventing the intermingling of ingredients between compartments during transporting and unloading. Compartments shall be of adequate size to contain the batch without mounding. Compartments shall have covers or other adequate protection against wind or rain. All gates shall be tight. The compartments shall be constructed to permit complete discharge of materials.

(F) Stationary Side Forms. Side forms shall be metal unless otherwise specified. Metal forms shall be of sufficient strength to resist concrete pressure and to adequately support all mechanical equipment operated on them without bending or deflecting.

Flexible or curved forms shall be used for curves of 100 foot radius or less.

Forms shall be equipped with a device for holding abutting sections firmly in alignment. They shall be adjustable for vertical and horizontal curvature.

Forms shall have a depth at least equal to the specified edge thickness of the concrete. Horizontal joints will not be permitted in the forms. The base width shall not be less than the depth. They shall be equipped with a minimum of three staking points per each ten foot length with a means of securely locking the form to each stake. Flange braces and staking pockets shall extend outward on the base not less than two-thirds the height of the form.

The use of wooden forms will not be permitted except by written approval. The use of wood forms will be considered for approval only in cases of extreme necessity. Any request for approval of use of wood forms shall include complete details indicating conformance to requirements for steel forms as to strength, lines, grades, and depth.

Forms with battered top surfaces, and bent, twisted, or broken forms

shall not be used. Repaired forms shall not be used until inspected and approved.

(G) Placing, Consolidating and Finishing Equipment. In general machine equipment will be required to place, consolidate and finish concrete in accordance with the best general concrete paving practices.

(I) Slip Form Pavers. The slip form paver shall be designed and equipped with automatic controls to control longitudinal and transverse grade. The grade control sensing device shall operate from an approved erected stringline.

The slip form paver shall be self-propelled with sufficient power to satisfactorily place and finish the concrete and negotiate all grades encountered without application of external tractive force.

The sliding forms shall be laterally rigid to prevent spreading.

The slip form paver shall effectively consolidate the plastic concrete for the full paving width by internal vibration. Vibrating units shall operate within the specified thickness of paving section and a minimum distance ahead of the screed at least equal to the pavement thickness.

The concrete may be consolidated by transverse vibrating units and/or a series of longitudinal vibrating units. Vibrating units may be either the immersed tube type or a series of equally spaced longitudinal vibrating units.

The spacing of each unit in a series of longitudinal units shall not exceed 24 inches measured center to center of the units.

The rate of vibration of each vibrating unit shall not be less than 7000 vibrations per minute and the amplitude shall be sufficient to be perceptible on the surface of the concrete along the entire length of the vibrating unit and for a distance of at least one foot therefrom. The contractor shall have available on the paver a tachometer or other suitable device for measuring and indicating the actual frequency of vibration.

When operated on an adjacent in place pavement, the slip form paver shall be equipped with rubber tires or protective pads on crawler units to prevent damage.

(2) Auxiliary Finishing Equipment. Machine finishing equipment that may be used behind the slip form paver shall be equipped to automatically maintain alignment from an external reference.

Where application of water to the surface is necessary for proper finishing it shall be applied only by equipment producing a fine mist or fog spray, approved by the engineer.

The contractor shall provide sufficient hand floats, edging tools and

other hand finishing equipment as necessary to finish the surface to the required tolerance.

(3) Stationary Side Form Method. Machine equipment shall be used for spreading, strike-off, consolidating, screeding and floating. Details of all equipment in the proposed paving train shall be submitted for approval prior to use.

(4) Roadbed Planers. The roadbed planer shall consist of steel cutting edges mounted in a rigid frame which is supported by wheels riding on the forms or adjacent slab. The cutting edges shall be adjustable as to crown and elevation. The planer shall have sufficient weight to trim off high spots encountered on the roadbed between the forms, and the frame shall be sufficiently rigid to maintain the required crown under all operating conditions. Wheels which are supported by an adjacent slab shall have no flanges in contact with that slab.

(5) Concrete Spreaders. The spreader shall be a self-propelled machine, equipped with a power-driven device for spreading the concrete uniformly between the forms, and provided with an adjustable blade or other approved means for striking off the concrete to the required height and crown. The spreader shall be equipped with effective cleaning devices to insure proper contact at all times between the wheels and the top of the forms or adjacent slab. Wheels which are supported by an adjacent slab shall have no flanges in contact with that slab.

(6) Vibrators. Vibrators, for full width vibration of concrete paving slabs, may be either the surface pan type or the internal type with either immersed tube or multiple studs. The vibrators may be attached to the spreader or the finishing machine, or may be mounted on a separate carriage. They shall not come in contact with the joint, load transfer devices, subgrade, or side forms. The frequency of the surface vibrators shall not be less than 3,500 impulses per minute and the frequency of the internal type shall not be less than 5,000 impulses per minute for tube vibrators and not less than 7,000 impulses per minute for spud vibrators.

When spud type internal vibrators, either hand operated or attached to spreaders or finishing machines, are used adjacent to forms, they shall have a frequency of not less than 3,500 impulses per minute.

(7) Transverse Finishing Machines. Each transverse finishing machine shall be self-propelled and shall be equipped with two or more reciprocating transverse screeds capable of being independently operated. At least one screed on each machine shall have a minimum width of 12 inches. All screeds shall be adjustable to the required crown of

the pavement. When the pavement contains areas of transition between varying rates of crown, at least one screed of the finishing machine shall be a quick-adjustable type which can be incrementally adjusted to the required crown without interrupting the forward progress of the machine. When more than one finishing machine is used simultaneously, only the rear machine shall be required to have the quick-adjustable screed. Each machine shall be equipped with effective cleaning devices to insure proper contact at all times between the wheels and the top of the forms or adjacent slab. Wheels which are supported by an adjacent slab shall have no flanges in contact with that slab.

(8) Mechanical Floats. The mechanical float for concrete pavement may employ any approved longitudinal, transverse, or diagonal floating action that will produce a surface true to the required crown and smoothness and free from honeycomb or excessive mortar. The float shall be accurately adjustable to the required crown and shall include means for making incremental adjustments in crown without interruption in the operation of the float. The mechanical float may be a self-propelled machine or it may be attached to the rear of the transverse finishing machine. The float shall be equipped with effective cleaning devices to insure proper contact at all times between the wheels and the top of the forms or adjacent slab. Wheels that are supported by an adjacent slab shall have no flanges in contact with that slab.

(9) Bridge Deck Finishing Machines. As approved under Article 39.04 (A) bridge deck finishing machines of the transverse finishing rotating drum type may be used when stationary side forms are allowed.

39.04 CONSTRUCTION METHODS

(A) General. Unless otherwise stated in the plans or special provisions all Portland Cement Concrete Pavement, with the exception of bridge approach slabs, ramp tapers, and other small restricted or irregular areas shall be placed by the slip-form method. The engineer may approve the use of the stationary side form method on projects of less than 20,000 square yards of Portland Cement Concrete Pavement.

(B) Proportioning and Measuring. Proportion and measuring shall be in accordance with Article 40.03.

(C) Mixing. A central mixing plant or central proportioning plant shall be used. Concrete may be mixed in central plant mixers or in truck mixers of an approved type and capacity conforming to Article 39.03(D).

Concrete shall be mixed in a central plant mixer for a period of not less

than one minute. The required time of mixing may be reduced, with the approval of the Engineer when modern paving plants are employed which are capable of accomplishing adequate and homogeneous mixing in a shorter time.

The mixer shall be operated at the drum speed shown on the manufacturer's name plate. Any concrete mixed less than the specified time shall be dumped outside the work and removed at the contractor's expense. Except by written permission, the mixer shall not be operated in excess of its guaranteed capacity as shown on the standard rating plate on the machine. Pick-up and throwover blades in the drum of the mixer, which are worn down three-quarters of an inch or more in depth, shall be replaced by new blades.

The intermingling of batches will not be permitted. The skip and the throat of the drum shall be kept free and clean.

Retempering concrete by adding water or by other means will not be permitted. Concrete not in place within 45 minutes from the time the ingredients were charged into the mixing drum, or that has lost plasticity to the extent that it will not meet slump requirements, shall not be used. High early strength cement concrete will be subject to additional limitations. Concrete shall not be mixed during cold weather. Materials containing frost shall not be used. Fine aggregate containing lumps or hardened material shall not be used.

The first batch of concrete material placed in the mixer shall contain an additional quantity of sand, cement and water. The additional materials shall be used to coat the inside surfaces of the drum without diminishing the mortar content of the mix. The mixer shall be thoroughly cleaned upon the cessation of mixing for any considerable length of time.

Concrete may be mixed in an approved truck mixer. The mixing speed of the drum shall not be less than four nor more than 15 revolutions per minute. The agitating speed of the drum shall be not less than two nor more than six revolutions per minute.

The volume of mixed concrete permitted in the drum of truck mixers shall not exceed the manufacturer's rating on the capacity plate.

Water, cement and aggregates shall be introduced at a central plant. On approval by the engineer, water, cement and aggregates may be introduced into the mixer in any sequence which produces a concrete that meets all other requirements of the specifications, except that cement and water shall be batched as simultaneously as batching equipment will permit. Water shall not be introduced in transit. Water may be introduced into the mixer at the job site under the direction of the engineer, provided that the designated water-cement ratio of the concrete is not exceeded.

The drum shall revolve continuously after the introduction of the cement and water, until the concrete is discharged therefrom.

Mixing shall commence immediately after introduction of the cement and water and shall continue for at least 70 revolutions of the drum at mixing speed. Not more than 100 revolutions of the drum shall be at a speed in excess of six revolutions per minute. Any other revolutions shall be at agitating speed or not less than two nor more than six revolutions per minute.

Concrete may be partially mixed by central plant mixing provided the mixing is completed by truck mixing, in which case central plant mixing shall be in accordance with the requirements of Article 39.04 (C) except that the mixing time at the central plant may be reduced to 30 seconds. The additional truck mixing shall be in accordance with the requirements of Article 39.04 (C) except that the volume of mixed concrete allowed in the drum, shall not exceed the manufacturer's recommendation.

(D) Transporting Concrete. All concrete shall be transported in equipment conforming to Article 39.03 (E). Plant-mixed concrete may be transported in non-agitated vehicles provided that the concrete is delivered to the site of the work and discharge is completed within 45 minutes after the introduction of mixing water to the cement and aggregates and provided the concrete is in workable condition when placed.

When a central porportioning plant is used the loose cement may be placed in batch boxes between the coarse and fine aggregate, provided batch boxes so loaded, which stand more than five hours and less than eight hours, shall have additional cement added thereto in an amount equal to 25 percent of the standard quantity required, and batch boxes which stand eight to twelve hours shall have additional cement added thereto in an amount equal to 50 percent of the standard quantity required. Materials in batch boxes, so loaded, which stand more than twelve hours shall not be used. Where such method of loading is used, loaded batch boxes shall be suitably covered to exclude water in case of rain and to prevent loss of cement due to wind. Alternate methods of loading batched aggregates and cement must be approved in writing, prior to use.

(E) Placing Concrete. The concrete shall be distributed to such depth above the grade that, when consolidated and finished, the slab thickness required by the plans will be obtained at all points and the surface will not at any point be below the grade specified for the finished surface.

Concrete shall be placed only on a foundation course, or subgrade, which has been approved. Concrete shall not be placed on a frozen

foundation course or subgrade. At all times during operation, at least 500 feet of foundation course, or one day's run of concrete shall have been prepared ahead of the mixer. No concrete shall be placed around man-holes or other structures until they have been brought up to the required grade and alignment.

The concrete shall be deposited on the foundation course, or subgrade, in such a manner as to require as little rehandling as possible. Concrete along the forms shall be consolidated by vibration.

Whenever it becomes necessary to stop the mixer, hand mixing shall be resorted to if necessary and a transverse construction joint shall be constructed as shown on the plans and as hereinafter specified. Except as above provided, no joint of any kind shall be placed across the pavement at any other location than that directed or shown on the plans. The pavement shall be constructed to its full width of the lane in a single construction operation. Longitudinal joints between lanes or sections shall be constructed in accordance with the details shown on the plans. Concrete in a longitudinal section shall not be placed until the adjacent parallel slab has attained an age of 14 days or has attained a compressive strength of at least 2,000 lbs./sq. in. as shown by test of standard specimens cured under the same climatic and moisture conditions as the slab. The mixer shall be located outside the lane of pavement being laid unless otherwise permitted, in writing.

(F) Slip Form Method.

(1) General. The concrete shall be placed with an approved slip form paver, conforming to Article 39.03 (F), designed to spread, consolidate, screed, and float finish the freshly placed concrete in one pass in such a manner that a minimum of hand finishing is necessary to provide a dense homogeneous pavement in substantial conformance to the plans and specifications. The alignment and elevation of the paver shall be regulated automatically from an approved external erected stringline.

(2) Finishing Concrete. The concrete shall be distributed uniformly into position by the slip form paver without delay.

The concrete shall be held at a uniform consistency, having a slump of not more than two inches and not less than one inch. The slip form paver shall be operated with a continuous forward movement and all operations of mixing, delivering and spreading concrete shall be so coordinated as to provide uniform progress with stopping and starting of a paver held to a minimum. If, for any reason, it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped immediately.

The paver may be set to form a battered edge of not more than three inches while maintaining the top riding surface at the specified width.

Additional hand vibration shall be provided at construction joints whenever judged necessary by the engineer.

After the concrete has been given a preliminary finish by means of finishing devices incorporated in the slip form paving equipment, the surface of the fresh concrete shall be checked by the contractor with a straightedge device not less than ten feet in length. At least one ten foot straightedge in good condition with a handle three feet longer than one half the width of the pavement being placed shall be available at the work area at all times. The purpose of the ten foot straightedge is to check the effectiveness of the finishing machine. It shall not be used to float the entire surface of the concrete. High areas indicated by the straightedge device shall be removed by the hand float method. Each successive check with the straightedge device shall lap the previous check path by at least one-half of the length of the straightedge. The requirements of this paragraph may be waived if it is successfully demonstrated that other means will consistently produce a surface with a profile that will conform to the ten foot straightedge requirements specified in Article 39.04 (M).

Any edge slump of the pavement, exclusive of specified edging, in excess of one-quarter inch shall be corrected before the concrete has hardened. If edge slump on any one foot or greater length of hardened concrete exceeds one inch, the entire panel between the transverse and longitudinal joints shall be removed and replaced with concrete true to the specified line, grade and cross section.

High spots exceeding one-quarter inch shall be reduced by suitable grinding methods. Low spots exceeding one-quarter inch shall be filled with an approved epoxy bonded grout in a manner directed by the engineer.

Before the concrete has taken its initial set, the edges of the pavement on each side of transverse expansion joints, formed joint, transverse construction joints, and emergency construction joints shall be worked with an approved tool and rounded to the radius required by the plans. A well-defined and continuous radius shall be produced and a smooth, dense mortar finish obtained.

Hand finishing will not be permitted except for the finishing of sections with narrow, irregular dimensions and in the event of machinery breakdowns to finish any concrete already deposited on the grade.

(G) Stationary Side Form Method.

(1) Preparation of Subgrade or Foundation Course. After the roadbed has been finished and compacted in conformity with the requirements of Section 11, the subgrade, or foundation course if called for, shall be placed, trimmed, shaped and compacted to the lines, grades and cross-sections shown on the plans or staked by the engineer and for an additional distance of two feet on each side, beyond the pavement width, in conformity with Section 20. The surface of the subgrade or the foundation course shall conform to the lines, grades, crown and cross-sections shown on the plans and to the requirements of Article 20.06, prior to setting the form.

After the forms have been set and approved, the subgrade or foundation course shall be reshaped and recompactd by accepted rollers or compactors operating between the fine grading equipment and the paver. The subgrade or foundation course shall be tested in advance of the paver for crown, profile elevation and surface smoothness, by the use of an approved template held in a vertical position and moved backward and forward on the forms. The template shall be mounted on visible rollers and shall be designed so that its tooth edge conforms to the required shape of the subgrade and, when riding vertically on the forms, the toothed edge will represent the subgrade surface. Any excess material represented by this template shall be removed. Low areas likewise found shall be brought up to correct elevation with approved subgrade or foundation material and compacted to the density specified for the embankment.

Equipment causing ruts in the finished subgrade or foundation course shall be corrected or removed from the work. The finished subgrade or foundation course shall be maintained in a smooth, compacted and undisturbed condition until the pavement is placed.

The subgrade or foundation course shall be in a moist but not muddy condition at the time of placing the concrete. If required, it shall be wetted the previous night or not less than six hours previous to placing of concrete. If it subsequently becomes dry, the subgrade or foundation course shall be sprinkled, but the method of sprinkling shall not be such as will form mud or pools of water.

(2) Form Setting. The forms shall show no variation greater than one-eighth inch from the true plane of the face or top of the forms. The forms shall be free from warp, bends or kinks.

The foundation course or the subgrade, under the forms, shall be hard and cut true to grade so that the form, when set upon it, will be firmly in contact for its entire length at the desired grade. Any foundation course

which, at the form line, is found below the established grade shall be filled to grade in lifts of one-half inch or less for a distance of 18 inches on each side of the base of the form and thoroughly compacted to the specified density. Imperfections and variations above grade shall be corrected by compacting before or after the form is set. No settlement or springing of forms under the finishing machine will be tolerated.

Conformity of the alignment and grade elevation of the forms with the alignment and grade elevation shown on the plans will be checked, and necessary corrections made by the contractor immediately prior to placing the concrete. Where any form has been disturbed or any foundation course thereunder has become unstable, the form shall be reset and rechecked.

Forms shall be set not less than 500 feet in advance of the point where the concrete is being placed to insure proper construction and inspection of the foundation course. Forms shall remain in place at least twelve hours after the concrete has been placed against them unless earlier removal is necessary to permit sawing of transverse weakened plane joints. Forms shall be cleaned and oiled each time they are used. The contractor shall exercise extreme care in removing forms to avoid any damage to the pavement edges.

(3) Strike-Off and Consolidation. The concrete, as soon as placed, shall be accurately struck-off and screeded, with approved machine equipment, to the crown and cross-section shown on the plans to such elevation slightly above grade that when properly consolidated and finished the surface of the pavement shall be at the grade elevation indicated by the plans.

The machine equipment shall be of the screeding and troweling type, equipped with two independently operated screeds, to strike-off and consolidate the concrete. It shall be subject to approval. The machines shall go over each area of pavement as directed as many times and at such intervals as is necessary to give the proper compaction and to leave a surface of uniform texture, true to grade and crown. Prolonged operation over a given area shall be avoided. The tops of the forms shall be kept clean by an effective device attached to the machine and the travel of the machine on the forms shall be maintained true without lift, wobbling, or other variations tending to affect the precision finish. The finishing machine shall be of ample strength to withstand severe use and shall be fully and accurately adjustable for loss of crown or other malfunction due to wear. At least two trips of the finisher will be required over all pavement areas.

During the first pass of the finishing machine, a uniform ridge of concrete shall be maintained ahead of the front screed for its entire length. Except when making a construction joint, the finishing machine shall not be operated beyond that point where the above described surplus can be maintained ahead of the front screed.

(4) Floating. In this operation, a self-powered mechanical float shall be used. It shall be of a type having a sawing motion while held in "floating position" and passed gradually from one side of the pavement to the other. Movements ahead along the centerline of the road shall be in successive advances not more than one-half of the length of the float. Its design and manufacture shall be of a type and style which in operation will provide a smooth true section. All mechanical floats or other type of equipment proposed for use in this operation must have prior approval.

(5) Straightedge Finishing. After floating is completed, and while the concrete is still plastic, minor irregularities and score marks remaining in the pavement surface shall be eliminated by means of long-handled wood floats and straightedges. When necessary, excess water and laitance shall be removed from the surface transversely by means of a finishing straightedge. The long-handled floats may be used to smooth and fill in open-textured areas in the pavement surface, but the final finish shall be made with the straightedge. The use of long-handled floats shall be held to a minimum as necessary to correct local surface unevenness not taken care of by the float, but it shall not be used to float the entire pavement surface. Straightedges shall not be less than ten feet in length and may be operated from bridges and from the side of the pavement. A straightedge operated from the side of the pavement shall be equipped with a handle three feet longer than one-half the width of the pavement. The surface shall be tested in trueness with a straightedge not less than ten feet in length, which shall be held in successive positions parallel and at right angles to the centerline of the pavement in contact with the surface and the whole area covered as necessary to detect variations. The straightedge shall be advanced along the pavement in successive stages not more than one-half its length. Depressions shall be immediately filled with freshly mixed concrete, struck-off, consolidated and refinished. Projections above the required elevations also shall be struck-off and refinished. The straightedge testing and finishing shall continue until the entire surface is free from observable departure from the straightedge, conforms to the required grade and contour and, when the concrete is hardened, will conform with the surface requirements specified under this Article, 39.04 (M), Surface Test.

The engineer may permit or require the application of a fine mist or fog spray of water to the surface of the concrete being finished when weather conditions cause rapid drying of the pavement surface. When used, the water shall be applied in an approved manner and in the minimum amount required to properly finish the pavement surface.

(H) Final Surface Finish. The final surface finish shall be accomplished by grooving the plastic concrete transversely to an approximate depth of one-eighth to three-sixteenths inches. This shall be done by approved mechanical equipment utilizing rectangular or circular spring steel tines 0.08 inch square or in diameter and evenly spaced one-half inch center to center. The final surface finish of narrow irregular shaped ramp taper sections shall be accomplished by grooving the plastic concrete to an approximate depth of one-eighth to three-sixteenths inches using steel tine hand rakes.

The grooving produced by hand methods shall closely conform to the grooving accomplished by mechanical equipment.

The final surface finish of bridge approach slabs shall be accomplished by grooving the plastic concrete to a depth of 0.01 feet by either mechanical equipment or steel tined hand rakes.

If grinding of high spots or the filling of low spots results in the loss of the required surface texture, the affected area shall be regrooved to the approximate same texture as the surrounding pavement. No additional cost will be allowed or considered for regrooving.

(I) Protection of Concrete. In order that the concrete may be protected against the effects of rain, the contractor shall have available at all times materials for the protection of the edges and surface of the unhardened concrete. Such protective materials shall consist of metal or wood having a width of not less than the thickness of the pavement at its edge for the protection of the pavement edges, and covering material such as burlap or cotton mats, curing paper, or plastic sheeting material for the protection of the surface of the pavement. When rain appears imminent, paving operations shall stop and all available personnel shall begin placing forms against the sides of the pavement and covering the surface of the unhardened concrete with the protective covering.

(J) Curing.

(1) Membrane. After the concrete has been finally finished and the free water has left the surface, the entire area of the pavement surface shall be sealed, by hand or machine spraying, using a uniform application of curing compound, specified in Article 39.02 (O). The solution shall be

applied in one or two separate applications as may be recommended by the manufacturer and as directed. If the solution is applied in two increments, the second application shall follow the first application within thirty minutes. The contractor shall provide satisfactory equipment and means to properly control and assure the direct application of the curing solution on the pavement surface so the result is a uniform coverage in the pavement at the rate of one gallon for each 150 square feet of area. Satisfactory equipment and means to control and apply the curing solution shall be construed as being whatever appliances and methods that are needed to prevent the loss of any of the solution during the application, together with an approved means of measuring the quantity to be applied and to insure complete and uniform coverage of the pavement.

If rain falls on the newly coated pavement before the film has dried sufficiently to resist damage, or if the film is damaged in any other way, the contractor will be required to apply a new coat of material to the affected portions equal in curing value to that specified. All areas cut by finishing tools subsequent to the application of the curing solution shall immediately be given new applications at the specified rate.

The contractor shall provide, on the job, sufficient burlap for the protection of the pavement in case of rain or breakdown of the spray equipment. In the event that hair checking develops before the curing compound can be applied, the procedure shall be modified in that initial curing with wet burlap, cotton mats or other approved material, shall be performed before the curing compound is placed.

(2) Wet Burlap or Cotton Mats. Preliminary curing may be accomplished by covering the entire surface of the pavement with blankets of wetted burlap, cotton fabric or other material of highly absorptive quality, previously approved by the engineer, laid directly upon the finished surface as soon after finishing as possible without marring the surface. The material shall be kept saturated in place for at least thirty hours.

For completion of the curing, the mats used for the preliminary curing period may be left in place and kept saturated for ninety-six hours or may be removed at the end of thirty hours, and immediately sealed with the curing compound specified in Article 39.02 (O).

(K) Handling and Placing Reinforcement. The concrete shall be reinforced if designated on the plans. Reinforcing metal shall be kept clean and free from rust, straight and free from distortion, and shall be placed and held in position as detailed. All metal received on the job shall

be held in approved storage and only such metal shall be distributed along the work as is needed for immediate placement.

When bar mat assemblies are shown on the plans, the reinforcement shall be assembled accordingly, firmly fastened together at all intersections. All adjacent ends shall lap not less than forty diameters. Mat assemblies shall be placed by methods satisfactory to the engineer so that no displacement will occur during concreting operations. "Sleds" shall not be used except those shown on the plans and designed so as not to form planes of latent weakness. When steel fabric is required, it shall be placed in strips transversely with the roadway at the depth and with the lap shown on the plans. The fabric shall extend to within two inches of the ends and sides of the slabs. The concrete shall be struck off by means of a template at the indicated depth of the reinforcing below the finished surface of the slab. The fabric reinforcement shall then be placed directly upon the concrete and properly secured so that it will remain in place while concrete is placed above it.

(L) Joints. Joints conforming to the Standard Drawings and plans shall be placed as noted. All costs incidental to joint construction shall be included in the contract unit price for concrete pavement.

(1) Transverse Expansion Joints. Transverse expansion joints, when called for, shall be formed during the placing of the concrete and such methods of construction shall be employed at joints so the full depth and width of the slabs are secured. The finished joint shall be true to the line prescribed within an allowable variation of one-quarter inch in the width of one traffic lane.

The preformed expansion joint filler shall conform to AASHTO M-90, shaped to the dimensions shown on the plans.

A string shall be stretched between the pavement forms along the centerline of the joint. The entire assembly shall be carefully levelled up so that the dowels are held rigidly parallel to the pavement surface and parallel to the centerline of the pavement and free to slide in the dowel holes. Any grease scraped off the dowels in assembling the joint shall be replaced. Any excess grease on the dowel holders shall be removed.

The complete expansion joint assembly shall be placed directly beneath the string line so the vertical plane of the joint will be perpendicular to the finished surface of the slab, and at right angles with the centerline of the slab.

Transverse expansion joints of the preformed type shall be formed by securely staking perpendicular to the proposed surface of the pavement

and an approved "installing bar" or installing device, against which the preformed filler shall be fastened before placing the concrete.

The installing bar shall be a substantial metal plate or shape. It shall have a length one-half inch less than the proposed width of the slab in cross section and a width of one-fourth inch less than the proposed depth of the slab. It shall be staked in position so that the top edge, unless otherwise provided on the plan, will be three-fourths inch below the proposed pavement surface. The lower edge shall be cut to conform to the prescribed cross section of the subgrade. The installing bar shall be slotted from the bottom as necessary to permit the installation of the required dowels and may be further cut away at intervals along its length to allow the concrete to make contact with the preformed filler at close intervals. Suitable means shall be provided, on the bar, for facilitating its removal. Header boards, sheet metal holders or other devices used in lieu of the installing bar shall have prior approval.

The preformed joint filler shall be appropriately punched to admit the dowels. It shall be furnished in lengths of not less than ten feet. Where more than one section is allowed and used in a joint, the section shall be securely laced or clipped together. When in position, the filler shall be perpendicular to the surface of the pavement. The bottom edge of the filler shall project to or slightly below the bottom of the slab and the top edge, unless otherwise prescribed, shall be held about three-fourths inch below the proposed surface of the pavement in order to allow the finishing operations to be executed continuously. The top edge of the filler shall be protected, while the concrete is being placed, by a metal channel cap of at least gage 10 material, having flanges not less than 1½ inches in depth. The installing device may be designed with this cap, self-contained.

Where integral curb is specified by the plans, the joint filler shall provide full thickness of joint filler through the curb and shall be placed at the same position as that in the underlying pavement slab.

After the concrete has been placed on both sides of the joint and struck off, the installing bar shall be slowly and carefully withdrawn leaving the preformed filler in place. Before the installing bar or channel cap is completely withdrawn, the concrete shall be carefully spaded and additional freshly mixed concrete worked into any depressions left by the removal of the installing bar. The filler must be exposed for the full width of the slab. The installing bar shall be cleaned and re-oiled prior to each installation. After the removal of the side forms, the ends of the transverse joints at the edges of the pavement shall be carefully opened for the entire depth of the slab. Before the pavement is opened to traffic, preformed joints, in which the filler does not come flush with the surface, shall be sealed or topped

out with the filler prescribed for poured joints, leaving a neat uniform strip of filler material slightly below the surface of the pavement.

In case the filler material in an expansion joint is tilted or otherwise displaced by the strike-off or finishing machines, the filler and the accompanying dowel bar assembly shall be removed from the pavement and a complete new joint constructed at the same location.

(2) Expansion Joints at Structures.

Sealing Joints—Joints between structures and concrete approach slabs and between concrete approach slabs and concrete pavement shall be sealed in conformance with the details shown on the plans and the requirements of these provisions.

The completed sealed joint shall resist the intrusion of non-compressible material or other foreign matter into the joint and shall resist the infiltration of water into the joint.

(3) Transverse Construction Joints. Unless other prescribed joints occur at the same points, transverse construction joints conforming to details on the plans, shall be made at the end of each day's run or where interruption in the concrete operations of more than one hour occurs. An "installing bar" as prescribed for transverse expansion joints shall be used or a clean plank having a thickness of not more than three inches and cut to conform with the plan cross-sections of the slab with a beveled strip to form a keyway joint may be used as a header board. The installing bar shall be carefully removed and any surplus concrete on the subgrade shall be cleaned away and the fresh concrete deposited directly against the old.

(4) Transverse Contraction Joints. Transverse contraction joints shall be formed by sawing. The use of a polyethylene strip to form transverse contraction joints will not be permitted.

Sawed contraction joints shall be cut by means of an approved concrete saw. The joint shall not be sawed until the concrete has hardened to the extent that tearing and ravelling is precluded. Part or all of the joints shall be sawed before the pavement starts shrinking and before uncontrolled cracking takes place. The spacing of the joints that must be sawed early will depend on several factors but shall be at such intervals that will prevent uncontrolled cracking. Any procedure which results in premature and uncontrolled cracking shall be revised immediately by adjusting the sequence of cutting the joints or the time interval involved between the placing of the concrete or the removal of the curing media and the cutting of the joints.

The contractor shall provide, at the site of the work during sawing

operations, at least one standby saw in good working condition and an ample supply of saw blades.

The joint shall be sawed at the depth, spacing and lines shown on the plans. If there are gutters and curbs they shall be cut to the proper depth to prevent erratic cracking. Suitable devices and guide lines shall be provided to insure cutting the joint in a straight line and perpendicular to the centerline of the pavement.

All contraction joints in adjacent widths of multiple lanes shall be sawed before uncontrolled cracking occurs. Any procedure which results in premature and uncontrolled cracking shall be revised immediately.

Immediately after the sawing operation is completed the groove shall be flushed out with water under pressure, and then cleaned, with compressed air, of all dust, water and slurry. The groove shall be cleaned again with a strong jet of compressed air just prior to filling the groove with joint filler.

(5) Longitudinal Joints. Longitudinal joints shall be constructed as shown on the plans and all such joints, not made by a form shall be sawed true to line and perpendicular to the surface of the pavement. Sawing shall conform to the requirements specified for "Transverse Contraction Joints," Part (L) (I) preceding.

At the option of the contractor, longitudinal joints may be formed by sawing or insertion of a polyethylene strip $2\frac{1}{4}" \pm 1/8"$ deep and at least 10 mils thick. In the event of conflict between the polyethylene strip and the steel tines of the surface grooving equipment resulting in either unsatisfactory surface texture or displacement of the inserted polyethylene strip, further use of the polyethylene strip shall be discontinued and the remainder of the longitudinal joint shall be formed by sawing.

The contractor shall maintain a standby concrete saw on the job regardless of the type of longitudinal joint formed. Sawing will be required to repair any improperly placed plastic strips. No additional compensation will be considered or allowed for sawing and sealing to correct improperly placed plastic strips.

The joint material shall be inserted with a mechanical device that places the material in a continuous strip, except where intervening structures break the continuity of paving. Splices in the joint material will be permitted providing they are effective in maintaining the continuity of the joint material as placed. The joint material shall be placed in such manner that the top of the strip is not more than 0.01-foot below the finished surface of the concrete. The joint material shall not be deformed from a vertical position, either in the installation or in subsequent finishing opera-

tions performed on the concrete. The alignment of the finished joint shall be uniformly parallel with the center line of the pavement and shall be free of any local irregularity which exceeds 0.04-foot, measured by a twelve foot straightedge, except for normal curvature of center line alignment. The mechanical installation device shall vibrate the concrete during placing the strip sufficiently to cause the concrete to flow evenly about the joint material producing homogeneous concrete free of segregation, rock pockets or voids.

(6) Keyway Longitudinal Joints. Keyway joints shall be used at the locations shown on the plans where one longitudinal lane of pavement is to be constructed against another separately laid lane of pavement. The keyway joint shall be a tongue and groove joint, the tongue and groove shall conform to the plans.

Construction of the second abutting lane at the keyway joint will not be permitted until the concrete in the first lane has attained a compressive strength (AASHTO T-22) of at least 2,000 lbs. per square inch.

(M) Surface Test. After the concrete has hardened, the surface of the pavement shall be tested with a ten foot straightedge, operated parallel to the centerline of the pavement. During the test, each depression shall be successively spanned, each high spot touched by the testing edge, so as to reveal all irregularities. All portions of pavement showing a variation or departure from the testing edge of more than one-sixteenth inch per foot of distance, from the nearest point of contact with the testing edge or showing a total variation in excess of one-fourth inch from the ten foot straightedge, shall be corrected by grinding until the variations are within the above limits, provided, however, that where the methods used would result in an unsatisfactory surface, or where the grinding would result in a slab thickness less than specified or shown on the plan cross section, the affected portions of pavement shall be removed and replaced. All corrections of irregularities and removing and all replacing of pavement, shall be done at no cost to the Department. Areas of sections to be removed and replaced shall be accomplished in accordance with "deficient thickness," as specified in Article 39.08 (E).

(N) Stockpiling Aggregates. Stockpiling of aggregates shall be done in accordance with the provisions of Article 26.04 and the applicable provisions of Section 40.

39.05 OPENING TO TRAFFIC. Opening to traffic, including the contractor's vehicles, will not be permitted until the longitudinal joints have been completed and the compressive strength of six inch by twelve

inch cylinders, tested in conformity with AASHTO T-22 (is at least 3,000 pounds per square inch.)

If permanent shoulders are not in place, a temporary earth shoulder shall be placed against the outside pavement edges before traffic is allowed on the pavement.

Opening to all traffic shall not constitute a final acceptance of the pavement.

39.06 INTEGRAL CURB. Integral curb shall be the curb which is constructed monolithically with the pavement. Outside forms for the integral curb shall have a height not less than the specified height of the curb and shall conform to the requirements of Article 39.03 (F) and Article 39.04 (G) (2). The inside face of the integral curb may be formed by approved steel forms held straight and rigid in place by steel clamps or space bars attached to the outside form.

The integral curb may be constructed by an approved alternate method, which eliminates the use of an inside form. Sufficient additional concrete shall be placed against the outside form to construct the integral curb along with the concrete placed for the pavement. The inside face of the curb shall be formed by means of a special steel template or "mule" shaped to the dimensions and cross sections shown on the plans. The top edge of the integral curb shall be rounded with an edger to form the radii shown on the plans.

The inside face of the curb shall be finished true to the lines and grades shown on the plans and the finish shall be the same as specified for the concrete pavement including longitudinal floating and burlap drag finishing. While the concrete is still plastic, the surface shall be tested for longitudinal trueness with a straightedge and the surface shall meet the same surface requirements as specified for the concrete pavement.

Joints in the concrete pavement shall be continued through the integral curb at the same locations and shall be the same type of joint and constructed in the same manner as required for the concrete pavement.

The integral curb shall be cured in accordance with the requirements specified for concrete pavement.

Integral curb shall not be measured and paid for separately, but shall be included with and considered a part of the contract unit price for concrete pavement.

39.07 WEATHER AND NIGHT LIMITATIONS.

(A) General. Concreting operations shall be discontinued when

darkness prevents good workmanship in placing and finishing operations. Night operations may be conducted upon specific written approval and when an adequate and approved artificial lighting system is provided.

Except by specific written authorization, concreting operations shall not be continued when a descending air temperature in the shade and away from artificial heat falls below 40°F. nor resumed until an ascending air temperature in the shade and away from artificial heat reaches 35°F. No concrete shall be placed on a frozen foundation course or subgrade.

The contractor shall assume all risk of placing concrete in cold weather. Placing concrete during cold weather shall in no way relieve the contractor of the responsibility for proper results. Any concrete injured by frost action shall be removed and replaced at the contractor's expense.

Before work is permitted to start the contractor shall furnish recording thermometers which will record temperatures from 0° through 100°F. automatically and continuously, on a chart, for periods of not less than 24 hours. During cold weather concreting, recording thermometers shall be furnished to keep accurate records of curing temperatures. One such thermometer shall be provided for each 1000 feet of pavement or fraction thereof. The contractor shall furnish and place sufficient other type thermometers as deemed necessary at the locations designated by the engineer.

(B) Heating and Placing Concrete. When concrete is authorized during cold weather, the aggregates shall be heated, by either steam or dry heat, prior to being placed in a mixer. Heating equipment shall heat the material uniformly. Such heating shall preclude the occurrence of non-uniform moisture contents, contamination in the aggregates or overheated areas. The temperature of the mixed concrete shall not be less than 50°F. nor more than 90°F. at the time of placing it in the forms. If the air temperature at the time of placing the concrete is 40°F. or less, the aggregates and water shall be heated to not less than 70°F. nor more than 150°F. Material containing frost or lumps of frozen material shall not be used. Neither salt nor chemical admixtures shall be added to the concrete to prevent freezing.

(C) Protection of Concrete. During the curing period, if the air temperature is anticipated to fall below 32°F., a sufficient supply of dry straw, hay, grass or other approved blanket type insulating material shall be provided along the work for covering all pavement which has been in place for 7 days or less. If, at anytime, the ambient temperature drops to 32°F or less, the concrete pavement shall be protected as follows: between two layers of plastic sheeting the insulating materials, with the exception of commercial blankets, shall be spread loosely to a minimum depth of six

inches, but in all cases to a sufficient depth to prevent freezing of, or frost damage to, the concrete. The blanketing material shall be maintained at least until the end of the regular specified curing period, which period shall not be less than seven days. The engineer may direct that the blanketing material remain for an additional period if the recorded temperatures indicate that additional curing may be necessary. If required by the engineer, concrete in place less than twenty-four hours shall be covered by approved heating enclosures and devices capable of maintaining the surface temperature of the concrete at not less than 50°F.

39.08 METHOD OF MEASUREMENT.

(1) Square Yard Measurement.

(A) Portland cement concrete pavement shall be measured by area in square yards and the yardage to be paid for shall be the number of square yards of concrete pavement of the specified thickness, including integral curb, completed and accepted, measured in place. The width for measurement will be the width from outside to outside of completed pavement, but not to exceed the width as shown on the plans or as ordered by the engineer. The length will be the actual length measured along the centerline of the pavement surface. Area constructed other than as pavement will be deducted from the area of pavement.

(B) Fillets for widened sections or at drainage structures and similar locations placed monolithic with the pavement will be measured and included as pavement. No deduction will be made for any fixture located within the limits of the pavement when such fixture has a surface area in the plane of the pavement surface of nine square feet or less.

(C) Pavement will be measured to the nearest one-tenth square yard.

(D) It is the intent of the specifications that pavement shall be constructed strictly in accordance with the thickness shown on the plans. The thickness of the pavement shall be measured and where any pavement is found not so constructed, such pavement may be compensated for at an adjusted unit price per square yard, or such pavement may be removed and replaced with satisfactory pavement.

(E) **Deficient Thickness.** If so ordered, pavement thickness may be determined by cores taken from the completed pavement in accordance with Montana Test Method M.T.-106. Cores will be taken, one for each one-half mile of two-lane pavement in alternate lanes and at such other locations as the engineer may direct. Pavement slabs which are deficient

in thickness by more than one half inch may, if so ordered be removed and be replaced at no cost to the Department with concrete of required thickness which, when accepted, shall be included in the pay yardage. If pavement slabs deficient in thickness by more than one-half inch are left in place, compensation for these sections shall not exceed 50 percent of the bid price. Pavement slabs deficient in thickness by more than three-fourths inch shall be removed and replaced at no expense to the Department. Deductions for deficiency in thickness are herewith tabulated:

DEFICIENT THICKNESS	PROPORTIONAL PART OF CONTRACT PRICE ALLOWED
1/8 in. to 1/4 in.	90%
Over 1/4 in. to 1/2 in.	75%
Over 1/2 in. to 3/4 in.	50%

In removing pavement that is deficient in thickness, the pavement shall be removed from the edge to a longitudinal joint, or between longitudinal joints and on each side of the deficient measurement until no portion of the exposed cross section is more than one-eighth inch deficient, except that in no instance shall there be less than ten linear feet of pavement removed. If, in meeting the above requirements, there remains less than five feet of acceptable pavement between the section that has been removed and a transverse plane of weakness (contraction, expansion or construction joints), then the contractor shall remove the pavement to the plane of weakness. The contractor shall then replace with satisfactory pavement all of the pavement that has been removed. Deductions for deficient thickness may be entered on any estimate after the information becomes available.

(F) Material used as a foundation course for the concrete pavement shall be measured in accordance with the item as bid and in agreement with the provisions of the section pertaining to that material.

(2) Cubic Yard Measurement.

(A) Portland cement concrete payment shall be measured by volume in cubic yards of Portland cement concrete accepted and placed.

The volume of cement concrete in cubic feet per batch shall be calculated by determining the weight per cubic foot of a batch in accordance with Montana Test Method No. M.T.-509 and dividing the result into

the total accumulated weight of cement, aggregates and water used in that batch.

The volume of cement concrete per batch shall be determined at least twice daily or oftener, if considered necessary by the engineer.

The volume per batch for each day's paving run shall be determined by averaging all volume determinations made that day.

The volume of cement concrete for payment for each day's run shall be the total number of batches accepted and placed, multiplied by the volume per batch determined as outlined above.

(B) It is the intent that Portland cement concrete pavement be constructed of variable thickness in substantial conformance to lines and grades shown on the plans or established by the engineer. The minimum thickness shall be 7½ inches.

39.09 BASIS OF PAYMENT.

(1) **Square Yard Payment.** The yardage of completed and accepted Portland cement concrete pavement, measured as provided, with no additional compensation for excess thickness, shall be paid for at the contract unit price per square yard for "Concrete Pavement" with proper allowance made for any deductions for deficiency in thickness, which price and payment shall be full compensation for furnishing, hauling, preparing, placing, finishing, curing and protecting, and for all materials, joints and joint materials, dowels, tie bars, and spacer bars, and for all integral curb and for preparing the subgrade and foundation course, and for all other operations necessary to complete the work.

Material used as a foundation course shall be paid for as indicated in the contract and in accordance with the applicable section.

(2) **Cubic Yard Payment.** The quantity of completed and accepted Portland cement concrete pavement measured as provided shall be paid for at the contract unit price per cubic yard for "Concrete Pavement" which price and payment shall be full compensation for furnishing, hauling, preparing, placing, finishing, curing and protecting, and for all materials including cement, joints and joint materials, tie bars, and for all other work necessary except as otherwise provided in the contract.

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SECTION 40

PORTLAND CEMENT CONCRETE

40.01 DESCRIPTION. Portland Cement Concrete shall meet all specification requirements and shall be composed of Portland cement, aggregates, water and other materials as provided in these specifications.

(A) Air-Entrained Concrete. Air-entrained concrete shall be used in all parts of the structure or structures, except for Class "AS", "DS", or "Pre" concrete. Concrete shall contain an air-entraining agent. An air-entraining Portland cement shall not be used.

(1) Air-Entraining Agents. When an air-entraining agent is used, the engineer will determine the quantity of air-entraining agent required to produce concrete having the specified air content. This quantity shall not be varied except as directed.

(2) Entrained Air. Required air content shall vary with the size of aggregate used. The percentage of entrained air will be determined in accordance with Montana Test Method MT-102. Tests for entrained air will be made by the engineer on concrete containing the materials to be used in the work and employing the type of mixer and mixing procedure which will be used in construction.

40.02 CLASSIFICATION. Concrete is classified as set forth below. Each class of concrete shall be used in that part of the structure in which it is called for in the plans, or where specified. Concrete with prefixes "A" will contain 1-1/2 inch size aggregate and those with "D" will contain 3/4 inch size aggregate. Concrete with prefixes "D" may be substituted for concrete with prefixes "A", when requested in writing by the contractor and an approved mix is furnished by the Materials Engineer. The following requirements shall govern unless otherwise shown on the plans.

(A) Class "A" or "D" concrete is generally used for retaining walls, box culverts, and substructures.

(B) Class "AD" or "DD" concrete is generally used for all structural concrete. The contractor may substitute Class "DD" concrete for Class "AD" concrete. However, all concrete shall be bid as Class "AD" unless specified otherwise. This applies to all structural concrete.

(C) **Class "AP" or "DP" concrete** is generally used for concrete pavement on streets and highways and for similar purposes.

(D) **Class "AS" or "DS" concrete** is generally used for all concrete deposited under water and will not contain an air-entraining agent.

(E) **Class "Pre." concrete** shall be used in all prestressed items.

(F) **Class "F" concrete** may be used as setting for metal fence posts and braces and similar situations where concrete of high quality is not necessary. When Class "F" Concrete is to be used, the aggregates will be approved on the project. See Article 40.03 (D) for proportioning.

(G) **Class "AC - DC" concrete** is generally used for erosion control devices.

40.03 COMPOSITION OF CONCRETE. Upon receipt of the notice of award of the contract, the contractor shall furnish the engineer with names of suppliers and locations of sources of materials which he proposes to use, excepting when Class "F" or "AC-DC" is specified or is to be used. The engineer will arrange for submittal of samples for testing.

(A) Design.

(1) The design volume of coarse aggregate, fine aggregate and the minimum allowable cement measured into each batch shall be in accordance with the laboratory mix design.

(2) A laboratory mix design, specifying the minimum cement content, the quantity of fine and coarse aggregate and the maximum quantity of mixing water will be designed in accordance with TABLE I in Article 40.03 (D).

(3) The contractor shall be responsible for producing concrete having the required minimum compressive strength. The contractor may use additional cement, not to exceed eight bags per cubic yard, with the approval of the engineer.

(4) The contractor shall be responsible for proportioning the materials in accordance with the laboratory design. If concrete is to be placed by pumping, the mix design may be modified by the laboratory within the limits of these specifications, to facilitate the pumping operation.

(5) The laboratory mix design proportions shall be used so long as the materials are actually furnished from the sources originally named and so long as they continue to meet the requirements herein specified. The proportions may be subject only to slight changes in the relative quantities of fine and coarse aggregate for the purpose of promoting workability and

correcting for moisture in the aggregates. In no case shall the ratio of water to cement be greater than is specified in TABLE I in Article 40.03 (D), for the class of concrete involved.

(6) If the contractor wishes to change the source of materials, he shall notify the engineer who will secure samples of the new sources and submit them to the laboratory for approval and new mix designs.

(B) Class "F" concrete. When Class "F" concrete is to be used, the mixture shall consist of one part Portland cement, two parts of clean, hard, sharp sand that will pass a 4 mesh screen and four parts of clean, broken stone or gravel uniformly graded between 4 mesh and 1-1/2 inch gradings. Measurement may be by volume. Water shall not exceed six gallons per sack of cement. The materials require approval by the engineer. Class "A" or "D" concrete may be substituted for Class "F".

(C) Class "AC-DC" concrete shall meet the requirements of TABLE I in Article 40.03 (D). It shall be of low slump and of proper cement content but does not have compressive strength requirements. Class "A" or "D" concrete may be substituted for Class "AC-DC". The materials will require approval by the engineer and shall be proportioned in accordance with Article 40.03 (D). The sand shall pass a 4 mesh sieve and shall be clean, hard and sharp. The aggregate shall be uniformly graded between the 4 mesh and the maximum size, and shall be clean, broken stone or gravel. Measurement may be by volume.

(D) Proportioning. The concrete will be designed to meet the requirements of TABLE I — CONCRETE PROPORTIONING TABLE, shown on the following page.

Mix designs, using minimum cement contents, will be specified by the laboratory for each project and may be modified by the laboratory, at the written request of the contractor, to increase the cement content.

40.04 MATERIAL.

(A) Cement, Air-Entraining Agents, Admixtures and Epoxy Adhesives. The cement used in the work shall be a Portland cement of the type or types shown on the plans, provided, however, that when not so shown, the type or types used shall be Type II for regular concrete.

(1) Cement. Portland cement shall be low-alkali and conform to the requirements of AASHTO M-85, or ASTM C-150, Type I, II, III, IV or V as the case may be. Cement for Class "Pre" concrete shall be Type I, II, or III. Type II-A Cement shall not be used.

(a) Low-alkali Portland cement shall have a total alkali content not

TABLE I — CONCRETE PROPORTIONING TABLE

Class	Size of Coarse Aggre- gate Square Mesh	Minimum Cement Content	Indicated Compres- sive Strength	Minimum Required Compres- sive Strength	Maximum Net Water Content Per Bag of Cement	Consis- tency Range in Slump	Required air Content
		94 lb. Sacks Per Cu.	7-Day Lbs. Per	28-Day Lbs. Per			
	Inches	Yd.	Sq. In.	Sq. In.	Gallons	Inches	Percent
A	1½	5.5	1600	2400	6.0	1½-3	4-6
D	¾	5.5	1600	2400	6.0	1½-3	5-7
AD	1½	6.5	2000	3000	6.0	1½-3	4-6
DD	¾	6.5	2000	3000	6.0	1½-3	5-7
AS	1½	7.0	1600	2400	6.0	4-8	—
DS	¾	7.0	1600	2400	6.0	4-8	—
AP	1½	6.0	2000	3000	6.0	½-2	4-6
DP	¾	6.0	2000	3000	6.0	½-2	5-7
*Pre.	¾	6.5	—	5000	—	—	—
F	1½	—	—	—	6.0	—	—
AC-DC	¾-1½	4.5	—	—	6.0	½-2	—

* - Concrete for Prestressed Beams. Compressive strength at transfer of prestress force shall be 4000 p.s.i. minimum. The strength shown at transfer of prestress and the 28-day requirement are for standard beams and will vary with beam length and designs. Check plans and specifications for each project.

exceeding 0.6 percent, calculated as the percentage of sodium oxide (Na_2O) plus 0.658 times the percentage of potassium oxide (K_2O). The total combination of C_3S , C_3A_4 shall not exceed 58 percent to comply to requirements after moderate heat of Hydration.

(b) Only one brand of any one type of cement shall be used on the contract except by written permission from the engineer. If more than one brand or grade is permitted by the engineer, they shall not be used alternately in any one pour. The contractor shall provide suitable means for storing cement and protecting it from dampness.

(c) Bags of cement shall be rejected if they have become partially set or contain lumps of caked cement. The cement from rejected bags, which is not partially set, caked or otherwise damaged, may be salvaged and used as bulk cement.

(2) Air-Entraining Agents. An air-entraining agent shall be added to the concrete mixture unless specified otherwise. The air-entraining agent being used shall not be changed without permission of the engineer. An approved air-entraining agent shall be added to prestressed concrete only if shown on the plans or directed by the engineer.

(a) Before any air-entraining agent can be used, evidence based on tests made in a recognized laboratory shall be submitted to show that the material conforms to the requirements of the latest revision of AASHTO M-154 (ASTM C-260) for 7 and 28-day compressive strengths and resistance to freezing and thawing, except as provided in the following paragraph. Tests for bleeding, bond strength and volume change will not be required. Tests may be made upon samples taken from a quantity submitted by the contractor for use on the project or upon samples submitted and certified by the manufacturer as representative of the air-entraining agent to be supplied.

(b) The contractor, in lieu of the requirements of the above paragraph, may submit certification from the manufacturer (not the supplier) attesting that the proposed material conforms to the requirements of the latest revision to AASHTO M-154 (ASTM C-260). The original copy of this certification will be kept on file by the Department and approval for the use of the material will be made to individual projects by memorandum. The contractor shall submit a signed statement attesting that the product furnished is the product represented by the manufacturer's certificate. The contractor shall be completely responsible for unacceptable results from the use of the product. The name of the product shall be listed in each certification and contractor's statement. An air-entraining agent proposed for use, that was approved for other projects, may be used after Department acceptance of the contractor's certification stating the name of the previously approved agent. A proposed air-entraining agent may be used if it is essentially the same as an approved agent (with only minor differences in concentration) and after Department acceptance of a contractor's certification stating the name of the agent and that no other admixture or chemical agent is present.

(c) The engineer may retest the air-entraining agent being used to determine its effect upon the strength of the concrete. When retested, the concrete shall not be less than 88 percent of the compressive strength of concrete of the same composition but without the air-entraining agent. The percentage reduction in strength shall be calculated from the average strength of at least 5 standard 6" x 12" cylinders of each type of concrete. Specimens will be made and cured in accordance with Montana Test

Method MT-101, and will be tested in accordance with AASHTO T-22. The percentage of entrained air will be determined in accordance with Montana Test Method MT-102. Air-entraining agents failing to meet these requirements may be rejected.

(d) A sufficient quantity of any of the approved agents shall be added with the mixing water. Should the contractor elect to use an approved metering device, he may use such other dilutions and quantities of solutions as the engineer determines will result in the proper control of the quantity of air-entraining agent.

(e) The mix design specified has had the necessary adjustment made in the weights of aggregates which are required to compensate for increased yield resulting from air-entrainment and no field adjustment shall be made. Any necessary adjustment will be made by the Helena laboratory.

(3) Admixtures. An admixture may be used, if advance permission is obtained from the engineer. No admixture shall be considered for approval which cannot show either certified laboratory test results or satisfactory field performance records to substantiate any and all claims made for the product. Admixtures shall meet the requirements of ASTM C-494.

(a) If a water reduction of at least 5% is made through the use of an admixture, a cement reduction may be made not to exceed 10% of the required cement content for all classes of concrete except class "AS" or "DS". In no case shall the resulting water cement ratio exceed 0.49 or 5-1/2 gallons per sack of cement. Compressive strengths shall be maintained in accordance with TABLE I Article 40.03 (D).

(b) Use of admixtures which contain calcium chloride will not be permitted.

(c) The contractor shall notify the engineer of the type of admixture to be used. A mix design will not be furnished until this information is received.

(d) Admixtures and air entraining agents shall be added to the mix water, each agent introduced separate from the other. Under no circumstance are these agents to be combined prior to their introduction in the mixing unit.

(4) Epoxy Adhesives. Epoxy Adhesives for highway construction shall meet the requirements of AASHTO M-234 specifications with one

exception. Paragraph 1.4.9 is hereby modified to permit thinning for use in sealing deck slab grind areas only.

Epoxy Resin Adhesives for bonding fresh to hardened concrete shall meet the requirements of AASHTO M-235 Class I specifications.

Epoxy Resin Adhesives for bonding hardened to hardened concrete shall meet the requirements of AASHTO M-235 Class II specifications.

Coal Tar Epoxy protective coating shall meet the requirements of AASHTO M-200 specifications.

(B) Water. All water used in concrete shall be subject to the approval of the engineer and shall be reasonably clear and free from oil, acid or alkali and vegetable substances, and shall not be brackish or salty. Water of doubtful quality shall be tested in briquettes as prescribed by Montana Test Method MT-109 and the strength of such briquettes shall be equal to similar briquettes made of water of known satisfactory quality.

(C) Aggregate. Aggregates shall meet the requirements of Section M-100.01. The gradation requirements shown in Article 40.04 (C) (1), (2) and (3) represent the limits which shall determine suitability for use from all sources of supply. The gradation shall be reasonably uniform and not subject to rapid change between the extreme percentages of gradation specified.

(1) Gradation. The gradation from any one source shall be reasonably uniform and not subject to change from the low to the high gradation limits specified in (2) and (3) below. The fineness modulus of representative samples taken from proposed sources shall be determined in accordance with AASHTO M-6. Fine aggregate from any one source having a variation in fineness modulus greater than 0.20 either way from the fineness modulus of the representative sample submitted may require a redesign of concrete mixes.

(2) Fine Aggregates.

(a) Fine aggregate shall meet the following gradation requirements:

Passing 3/8 inch sieve.....	- 100%
Passing 4 mesh sieve.....	95 - 100%
Passing 8 mesh sieve.....	65 - 95%
Passing 16 mesh sieve.....	35 - 80%
Passing 50 mesh sieve.....	5 - 30%
Passing 100 mesh sieve.....	0 - 10%
Passing 200 mesh sieve.....	0 - 3%

(b) Fine aggregates shall have a fineness modulus of not less than 2.50 nor more than 3.10. The application of the 0.20 variation shown above shall not cause the fineness modulus to be less than 2.50 nor more than 3.10.

(3) **Coarse Aggregates.** Coarse aggregate shall be furnished in two separate sizes.

(a) Separation of 1-1/2 inch material (No. 1) shall be made on a sieve which will result in a medium (No. 2) and a course (No. 3) aggregate meeting the specifications shown in TABLE II, Article 40.04 (C) (3) (b).

(b) The sizes of coarse aggregate designated shall meet the requirements of the following table.

TABLE II — COARSE AGGREGATES

Designated No.	Sizes	Percentage by Weight Passing Laboratory Sieves Having Square Openings							No. 4
		2	1½	1¼	1	¾	½	⅜	
1	4 to 1½"	100	95-100	70-95	—	35-70	—	10-30	0-5
2	4 to ¾	—	—	—	100	85-95	40-75	20-55	0-10
3	¾ to 1½"	100	90-100	55-90	20-55	0-15	—	—	—

(4) **Storage.** Aggregates shall be stored in compartmented bins, or some positive means shall be used to separate the different sizes. The inclusion of foreign material shall be prevented. Any difficulty experienced in complying with this requirement will be cause to stop work until wooden or concrete floors are installed. The different kinds of aggregates, if stockpiled, shall be separated and stockpiles of coarse aggregates shall be built up in successive horizontal layers not more than 3 feet thick. Each layer shall be completed before the next is started. Should segregation occur, the aggregate shall be remixed to conform to the grading requirements.

When ready-mixed concrete is used, stockpiles of acceptable aggregate may be required at the plant supplying the concrete. If any difficulty is experienced in complying with specification requirements for aggregates it will not be permissible to use aggregate directly from the ready-mixed companies' stockpiles and it will be necessary to establish separate stockpiles for Department work.

Contaminated aggregate removed from stockpiles shall be rejected.

(D) **Preformed Expansion Joint Fillers for Concrete.** Preformed expansion joint fillers shall meet the requirements of Section M-150.

40.05 CONSTRUCTION METHODS.

(A) **Handling, Measuring and Batching Materials.** Concrete of the classes specified shall be made up of acceptable material batched in the proportions specified by the laboratory mix design. Corrections necessitated by variations in the moisture content of the component materials or for other similar reasons shall be made as directed, based upon laboratory and field determination.

The contractor may weigh or measure the water. The cement, the fine aggregate and both sizes of coarse aggregate shall be weighed. The contractor may substitute approved volumetric measuring devices in lieu of weighing devices when batching aggregates for structures containing less than ten cubic yards of concrete. The weighing methods will require the approval of the engineer prior to the beginning of batching operations. The weighing equipment shall meet the following requirements:

(1) **Water.** The water shall be measured either by volume or weight. The allowable error in accuracy of water measuring or weighing equipment shall not be more than 2%. The weighing equipment shall be so arranged that the accuracy of the measurement will not be affected by variations in pressure in the water supply lines. An auxiliary tank from which the measuring or weighing tank is filled may be required.

When water is measured by volume it shall be metered through an approved recording water meter device. This device is required on all batching and mixing equipment during warm weather operations. Other approved methods of water measurement will be permitted during cold weather operations.

(2) **Cement.** Cement may be measured either by weight or by volume. Volume shall mean 94 pound bags as packed by the manufacturer. If the volume method is used, cement in all batches of concrete mixed shall be in full bags. No batch shall be run using fractional bags of cement. When cement is measured by weight it shall be weighed on a separate scale which is accurate and maintained within a maximum tolerance of one percent of the load being weighed.

(3) **Equipment for Weighing Aggregates.** The weighing equipment and weighing methods shall meet the following requirements:

(a) The capacity of the weighing equipment shall be adequate to permit weighing of materials without delaying the production of the mixer.

The balance or weighing mechanism shall be of the beam or springless dial type, and shall be so designed and built that it may be maintained within a maximum tolerance of one percent of the load being weighed. The weighing equipment shall be subject to such tests as the engineer deems necessary to determine its accuracy.

(b) The value of the graduations shown on the scale shall permit weighing of materials within the accuracy specified. The engineer will determine acceptability of the graduation value when fractional batches are used.

(c) Scales of the suspended hopper type shall be equipped with a telltale dial or similar device that indicates at least the last 50 pounds of load. The telltale dial or similar device shall be placed in a position that will allow easy observation by the batch operator.

(d) The batching plant may include bins, weighing hoppers and scales for the fine aggregate and for each size of coarse aggregate. A single weighing hopper with an accumulative scale will be permitted provided a separate scale is used for weighing the cement.

(e) The batch plant will be acceptable as meeting the requirements of having a separate scale for weighing the cement if:

1. The batch plant scales are maintained within the maximum tolerances that are specified for weighing cement;

2. If the cement is always weighed in a separate inner hopper of conventional design and;

3. If the cement is always batched and weighed first in the batching sequence.

(f) Batching plants will be permitted which are equipped to proportion aggregates and bulk cement by automatic weighing devices of an approved type.

(g) The contractor shall provide each scale installation with ten standard 50 pound test weights.

(h) Each batching plant shall be equipped with an acceptable electronic moisture meter device which indicates the moisture content of the fine aggregate. The registering dial shall be mounted in such a position that it will allow convenient observation by the batching operator.

(B) Consistency. Concrete shall be of such consistency that it will flow around reinforcing steel but individual particles of the coarse aggregate when isolated shall show a coating of mortar containing its proportionate

quantity of sand. The consistency of concrete will be gauged by the ability of the equipment to properly place the concrete in its final position and not by the difficulty in mixing or transporting. The quantity of mixing water used shall be the minimum necessary to provide workability within the ranges of slump specified. The quantity of the mixing water shall not be varied without approval.

(C) Mixing. Materials for concrete shall be handled, measured and batched in accordance with Article 40.03 (D). Concrete shall be thoroughly mixed in a manner to positively insure a uniform distribution of the materials throughout the mass. Concrete shall be mixed only in quantities required for immediate use and shall be used within the time limits specified. Any concrete in which initial set has begun shall be wasted. In no case will retempering of concrete be allowed. Aggregates, or bags of cement, containing lumps or crusts of hardened material shall not be used.

Concrete may be mixed by any of the following methods:

(1) Mixing with Stationary Mixer at Site.

(a) Concrete shall be thoroughly mixed in a batch mixer of approved type and capacity. The period of mixing after all materials including water are in the drum shall be a minimum of 1-1/2 minutes unless a lesser time is approved. During the mixing period, the drum shall be operated at drum speeds specified by the mixer manufacturer and shown on his nameplate on the machine. The entire contents of the mixer shall be removed from the drum before materials for the succeeding batch are placed therein. The mixer shall be equipped with mechanical means for preventing the addition of aggregates after mixing has commenced.

(b) The mixer shall be equipped with an approved timing device which will automatically lock the discharging device. The mixer shall not be emptied until the materials have been mixed the minimum specified time. No mixer shall be operated above its rated capacity. No mixer shall be used which has a rated capacity of less than a one-bag batch.

(c) The first batch of concrete material placed in the mixer shall contain an additional quantity of sand, cement and water. The additional materials shall be used to coat the inside surfaces of the drum without diminishing the mortar content of the mix. The mixer shall be thoroughly cleaned upon the cessation of mixing for any considerable length of time.

(2) Hand Mixing. Hand mixing will not be permitted, except in case of emergency and under written permission from the engineer. When

permitted, it shall be done only on water-tight platforms or containers. The sand shall be spread evenly over the platform and the cement spread upon it. The sand and cement shall then be thoroughly mixed while dry by means of shovels until the mixture is of a uniform color, after which it shall be formed into a "crater" and water added in a quantity necessary to produce mortar of the proper consistency. The material upon the outer portion of the crater ring shall then be shoveled to the center and the entire mass turned and sliced until a uniform consistency is procured. The coarse aggregate shall then be thoroughly wetted and added to the mortar and the entire mass turned and returned at least six times and until all of the stone particles are thoroughly covered with mortar and the mixture is of a uniform color and appearance. Hand mixed batches shall not exceed one-half cubic yard in volume. Hand mixing will not be permitted for concrete to be placed under water.

(3) Ready Mixed.

(a) The capacity of the plant and the transportation equipment shall be sufficient to ensure delivery at a rate which will permit proper handling, placing and finishing at the point of delivery. The rate of delivery of concrete shall be such as to provide for as continuous an operation of placing, handling and finishing concrete as is practical. The interval between delivery of loads shall be such that layers or lifts of concrete in place shall not harden before succeeding layers or lifts are placed. In general, no lift or layer of concrete shall remain exposed for more than 20 minutes before being covered by fresh concrete.

(b) The concrete shall be discharged at the job and placed in its final position in the forms within one and one-half hours after the introduction of the mixing water and cement. When the air temperature is 80° F. or above, the concrete shall be placed in its final position within one hour after the introduction of the mixing water and cement.

(c) Generally, no mixed or agitated concrete shall be used which has remained in the drum of the truck agitator or truck mixer more than ten minutes without agitation. However, if in the judgement of the engineer, the concrete has not suffered any detrimental effects, it may be used after remixing for a minimum of twenty revolutions of the drum at mixing speed and so long as it can still be placed in the forms within the specified time limits.

(d) A suitable revolution counter shall be provided on each truck which will register the number of revolutions of the drum. This counter

shall be mounted in such a position that it can be easily read from the ground by both the operator and the engineer.

(e) The method and time of delivery shall be controlled by plant slips issued to the driver and signed by the engineer or inspector at the plant. The slip shall be delivered to the inspector or engineer, upon arrival, at the site of the work.

(4) Central Plant Mixing. The mixer and methods used shall be in accordance with the requirements of Article 40.05 (C) (1).

(a) Mixed concrete shall be transported from the central mixing plant to the site of the work in approved agitator trucks or approved hauling vehicles. Unless otherwise permitted in writing, the agitator shall be a closed water-tight revolving drum. It shall be suitably mounted and shall be capable of transporting and discharging the concrete without segregation. The agitating speed of the drum shall not be less than two nor more than six revolutions per minute. The volume of mixed concrete permitted in the drum shall not exceed the manufacturer's rating nor exceed eighty percent of the gross volume of the drum.

(b) Concrete, transported in agitator trucks, shall be discharged at the job and placed in its final position in the forms within one and one-half hours after the introduction of mixing water and cement. When the air temperature is 85° F. or above, the concrete shall be placed in its final position within one hour after the introduction of the mixing water and cement.

(5) Truck Mixing. Concrete shall be mixed in an approved truck mixer. Truck mixing shall be in accordance with Article 40.05 (C).

(a) Unless otherwise permitted in writing, the truck mixer shall be a closed, water-tight, revolving drum. It shall be suitably mounted and shall be fitted with blades capable of combining all ingredients into a thoroughly mixed and uniform mass and of discharging the concrete without segregation. The mixing speed of the drum shall not be less than four nor more than fifteen revolutions per minute. The agitating speed of the drum shall be not less than two nor more than six revolutions per minute.

(b) The volume of mixed concrete permitted in the drum of truck mixers shall not exceed the manufacturer's rating on the capacity plate.

(c) When truck mixers are used during warm weather operations, a recording water metering device shall be provided to measure accurately the quantity of water for each batch or load. The device shall be

mounted on the truck mixer. During freezing weather other approved methods of measuring water will be permitted. A recording water metering device will always be required at the primary point of the batching operation.

(d) Water, cement and aggregates may be introduced either at a central plant or at the site of the concrete construction. On approval by the engineer, water, cement and aggregates may be introduced into the mixer in any sequence which produces a concrete that meets all other requirements of the specifications, except that cement and water shall be batched as simultaneously as batching equipment will permit. Water shall not be introduced in transit. Water may be introduced into the mixer at the job site under the direction of the engineer, provided that the designated water-cement ratio of the concrete is not exceeded. The drum shall revolve continuously after the introduction of the cement and water, until the concrete is discharged therefrom.

(e) Mixing shall commence immediately after introduction of the cement and water and shall continue for at least 70 revolutions of the drum at mixing speed. Not more than 100 revolutions of the drum shall be at a speed in excess of six revolutions per minute. Any other revolutions shall be at agitating speed or not less than two nor more than six revolutions per minute.

(f) The concrete shall be discharged at the job and placed in its final position in the forms within one and one-half hours after the introduction of the mixing water and cement. When the air temperature is 85° F. or above, the concrete shall be placed in its final position in the forms within one hour after the introduction of the mixing water and cement.

(g) Generally, no mixed or agitated concrete shall be used which has remained in the drum of the truck mixer more than ten minutes without agitation. However, if in the judgment of the engineer, the concrete has not suffered any detrimental effects, it may be used after remixing for a minimum of twenty revolutions of the drum at mixing speed and if it can still be placed in the forms within the specified time limits.

(h) A suitable revolution counter shall be provided on each truck which will register the number of revolutions of the drum. This counter shall be mounted in such a position that it can be easily read from the ground by both the operator and the engineer.

(6) **Partial Mixing at the Central Plant.** Concrete may be partially mixed by central plant mixing provided the mixing is completed by truck mixing.

(a) The central plant mixing shall be in accordance with the requirements of Article 40.05 (C) (4), except that the mixing time at the central plant may be reduced to thirty seconds. The truck mixing shall be in accordance with the requirements of Article 40.05 (C) (5), except that the volume of mixed concrete allowed in the drum shall not exceed the manufacturer's recommendation.

(D) Placing Concrete. Concrete shall be thoroughly compacted into its final position. It shall be well consolidated around fittings and embedded items. All reinforcement and other embedded items shall be accurately placed as shown on the plans and shall be thoroughly clean and substantially free from coating, detrimental rust, scale, oil or foreign matter. Concrete shall be placed in agreement with applicable requirements of Sections 39, 41 and 42.

(E) Curing Concrete. Concrete surfaces exposed to conditions causing premature drying shall be protected by covering as soon as possible with canvas, plastic sheets with sealed joints, burlap, sand or other satisfactory materials and kept continuously moist; or if the surfaces are not covered, they shall be kept continuously moist by flushing or sprinkling. Curing shall continue for a period of not less than seven days after placing the concrete. Other precautions to insure proper curing and the development of the required compressive strength, shall be taken by the contractor as directed. The surfaces of concrete placed against forms may be cured by leaving the forms securely fastened in place for a minimum of seven days, when approved.

In order to facilitate finishing, side forms on ornamental work, curbs and sidewalks, railings and parapets shall be removed in not less than 24 nor more than 48 hours depending on weather conditions. Moist curing shall continue during the concrete finishing operation.

Untreated forms and existing concrete shall be kept continuously wet for a period of not less than one hour before any concrete is placed therein. They shall be kept wet until covered with concrete except that adequately treated forms shall be thoroughly washed with a water spray immediately prior to placing the concrete.

The curing of concrete, accomplished by either water curing or membrane curing, shall be as follows unless otherwise approved by the engineer.

(1) Water Curing. All top surface concrete shall be kept continuously moist after finishing, with a fine water spray, until the concrete has set. The moist concrete shall then be covered with water or an approved curing covering.

(a) Concrete deck slabs and concrete floors shall be cured for a minimum of seven days. Curing shall be accomplished by placing burlap, cotton mats or other absorptive material as close behind the finishing operation as possible without marring the finished surface. The absorptive material shall be kept continuously moist for the full time it is used. The absorptive material may be kept in place for the entire curing period or it may be removed as soon as practicable and the entire surface covered with approximately one and one-half inches of sand which shall be kept continuously moist for the entire curing period.

(b) The removal of forms and the repair of surface irregularities shall be accomplished without interfering with any of the curing requirements. As soon as the vertical forms have been removed and the surface irregularities repaired, the concrete shall be completely covered with absorptive material which shall be kept continuously wet for the balance of the curing period.

(2) Impervious Membrane Curing. Membrane curing compounds shall comply with AASHTO M-148. It shall be delivered to the job in the manufacturer's original container, clearly labeled to show the name of the manufacturer and the contents. The clear curing compound shall be sufficiently transparent and free from permanent color to result in no pronounced change in color from the natural concrete. The clear compound shall contain a fugitive dye of color strength sufficient to render the film distinctly visible on the concrete for a period of at least four hours after application. The concrete surface shall resume its natural color, after curing.

(a) The material shall be ready for use as shipped by the manufacturer and no diluting will be permitted. No curing material shall be used without written approval. Sampling will not be necessary if manufacturer's certification is available. The curing compound shall be applied under pressure with a spray nozzle in a manner that will cover the entire exposed surface thoroughly and completely with a uniform film at the rate of not less than one gallon per 150 square feet of concrete surface. Sufficient pressure shall be maintained in the spray machine to force the material to leave the nozzle in the form of a fine mist. All concrete surface shall be kept moist with a fine water spray or with wetted burlap until the sealing compound is applied. The application of the curing compound shall be kept close to the finishers of the top surface of concrete at all times and the concrete shall be sealed immediately after the finishing operations have been completed, to the satisfaction of the engineer.

(b) If it is necessary to allow workmen, wheelbarrows, concrete

buggies and the like on the surface before the seven day curing period is completed, the top surface of sealed concrete shall be covered with a protective cushion for runways. This cushion shall consist of a moist one inch minimum thick layer of fine sand or at least two layers of moist burlap, and then the approved cushion shall be covered with four by eight foot sheets of three-quarter inch plywood laid over the cushion. The cushion material shall not be placed for at least eight hours after the final application of the curing compound. Any other proposed cushion material shall be approved in writing by the engineer before use. Layers of plastic, visqueen or canvas are not considered as an acceptable cushion material.

(c) Concrete, which has not completed its curing period, shall be kept continuously moist during the stripping and surface repair operations. The contractor shall remove all surface irregularities, repair all depressions, voids, or holes, including those formed by trapped air, to the satisfaction of the engineer. The curing compound shall then be applied immediately before the surface has had an opportunity to dry out. Concrete, from which forms have been stripped, shall be kept continuously moist until surface repair and finishing are completed and the impervious membrane curing has started.

(3) Water Soluble Liquid Membrane Curing. This method shall consist of spraying a uniform film of water soluble liquid membrane-forming compound over horizontal surfaces such as pavements, deck slabs, concrete floors, sidewalks and the like as required. Spraying shall begin immediately behind the final surface finishing operation. The rate of application shall be not less than one gallon of the concentrated compound per 250 square feet of surface. The water soluble liquid membrane-forming compound shall be mixed with water at the rate of 50 gallons of concentrated compound to 33 gallons of water and thoroughly mixed before use, or as approved by the Engineer.

The curing compound shall be applied by a self-powered machine with a mechanical pressure distribution system designed to provide uniform coverage of the surface at not less than the minimum specified rate of application. The spray nozzles shall be enclosed by a suitable hood to minimize loss of curing compound during windy conditions. An approved type of hand-operated sprayer may be used when liquid curing compound is applied to areas where the dimensions of the work or other features make the use of a self-powered sprayer impractical.

The material for Water Soluble Membrane Coating shall conform to the requirements of Article M-340.08, Concrete Protective Coating.

If the curing membrane is damaged from any cause during the

curing period, the damaged areas shall be recoated without delay. When side forms are removed prior to expiration of the curing period, the exposed sides of the pavement shall be sprayed with curing compound within 30 minutes after removal of the forms and at a rate not less than that specified for the surface of the pavement. If the compound, mixed as specified, is too viscous it may be diluted by addition of more water, however, the rate of application shall be adjusted to obtain the specified coverage. Precaution must be exercised when using the compound on vertical surfaces due to the fact that the membrane forming characteristic takes a short time to develop a film.

When "Protective Coat" is included as an item of the contract and the contractor selects Water Soluble Liquid Membrane Compound as the curing agent — he shall also have satisfied the requirements for "Protective Coat". No additional applications will be required for "Protective Coat". In this instance only, payment will be made under the item "Protective Coat".

40.06 TESTING AND ACCEPTANCE OF CONCRETE.

(A) Testing. A concrete test will consist of three or more cylinders made at the same time from the same batch of concrete. These cylinders may be broken at various ages to determine strength gain and maintain job control, but standard compressive tests will be made at 7, 14 and 28-days. The compressive strength results from one or a combination of the cylinders tested may be used to determine whether concrete meets the required compressive strength shown in TABLE I — Article 40.03 (D). Cylinders made in the field shall be cast and cured in accordance with Montana Test Method MT-101. Testing of concrete cylinders shall be in accordance with AASHTO T-22.

(B) Acceptance or Rejection of Concrete.

(1) The average of all the 28-day strength tests representing each class of concrete, as well as the average of any five consecutive 28-day strength tests representing each class of concrete, shall be equal to or greater than the required compressive strength.

(2) Not more than one test in ten consecutive tests shall fall below 90 percent of the required compressive strength.

(3) On projects where less than ten tests are made, not more than one test may fall below the required compressive strength. The average of all tests shall be equal to or greater than the required compressive strength; and paragraph (4) below will not apply.

(4) Not more than ten percent of all compressive strength tests may fall below the required compressive strength for each class of concrete.

(5) Concrete represented by tests that fail to meet the requirements of Articles 40.06 (B) (1), (2), (3), and (4) will be rejected, unless it can be established by other methods that the concrete is acceptable, in place, in the completed structure.

(6) Concrete transported in aluminum pipes, or chutes, troughs and the like lined with aluminum shall not be accepted. Concrete mixed in mixers or transported in agitator trucks equipped with aluminum parts which come in contact with the concrete ingredients shall not be accepted.

(7) Testing and acceptance of concrete in bridges will be based on Articles 40.06 (B) (1), (2), (3), (4) and (5) except that concrete tests falling below the compressive strengths shown in Table I, Article 40.03 (D) may be rejected if determined to be in critically stressed areas wherein the structural soundness of the unit is jeopardized.

(8) Concrete that is unsatisfactory will be rejected. All rejected concrete shall be removed and replaced by the contractor at no cost to the Department.

(C) Sampling Aggregates. The fine and coarse aggregates will be sampled in accordance with the method described in Montana Test Method MT-201 with sample sizes corresponding to those used in Montana Test Method MT-202.

40.07 METHOD OF MEASUREMENT. The method of measurement will be in accordance with Article 41.05, except that Class "AP" concrete will be measured in accordance with Article 39.08.

40.08 BASIS OF PAYMENT. The basis of payment will be in accordance with Article 41.06, except that Class "AP" concrete will be paid for in accordance with Article 39.09.

SECTION 41

CONCRETE STRUCTURES

41.01 DESCRIPTION. This work shall consist of constructing concrete structures, and concrete portions of prestressed concrete, steel, timber, stone masonry, and composite structures, in accordance with these and other specifications and to the lines, grades and dimensions shown on the plans or ordered in writing by the engineer.

41.02 FIELD OFFICE. The Department of Highways shall provide a field office for the engineer in accordance with the provisions of Article 06.05, unless otherwise specified.

41.03 MATERIALS. Except when otherwise specified, all materials used in this work shall be new and shall be those prescribed for the various items which constitute the structure. Specific references are made as follows:

- (A) ConcreteSection 40
- (B) Reinforcing Steel and Structural Steel..... Section M-290
- (C) Expansion Joint Filler..... Section M-150
- (D) Water stops Article M-150.03

41.04 CONSTRUCTION METHODS

(A) General. Requirements for specified construction, other than concrete, shall be as in other sections for the several items of work entering into the completed structure.

(B) Foundations. All foundations shall be prepared as specified under Section 45. No concrete shall be placed in a foundation that has not been inspected and approved. The elevations of the bottoms of footing as shown on the plans are approximate. The engineer may order, in writing, such changes in dimensions or elevations of footings as may be necessary to obtain satisfactory foundations. Revision of the plans for abutments, walls, piers, or bents will be made as needed.

(C) Falsework. Falsework for supporting concrete work shall be built on foundations of sufficient strength to carry the loads without detrimental deformation or settlement. Falsework which cannot be founded on solid footings must be supported by ample falsework piling. All spans shall be

given a temporary camber sufficient to allow for shrinkage and settlement. Bridges shall have a permanent camber only when shown on the plans.

The contractor shall include with his falsework a system which will allow adjusting and maintaining forms to the correct line and grade. "Tattle-tales" or other approved devices shall be provided at sufficient locations to indicate form settlements or deflections necessitating form adjustment. If detrimental settlement, which cannot be corrected, occurs in the falsework, the work shall be stopped, any masonry affected shall be removed and the falsework rebuilt.

If requested, detail drawings of the falsework shall be submitted to the engineer for approval, but such approval shall not relieve the contractor of any of his responsibility under the contract for the successful completion of the improvement.

(D) Forms. Forms shall be so designed and constructed that they may be removed without injuring the concrete. Unless otherwise specified on the Plans or in the Special Provisions forms or form members will not be allowed to remain in place.

The term "Exposed Surfaces" shall be those concrete surfaces which are above the finished ground line.

Unless otherwise specified, forms for exposed surfaces shall be made of plywood, hard-pressed fiberboard, or metal in which all bolt and rivet holes are countersunk. A plane, smooth surface of the desired contour shall result from the use of any type of form. Rough lumber or tongue-and-groove lumber may be used for surfaces that will not be exposed in the finished structure. All lumber shall be free from knotholes, loose knots, cracks, splits, warps, or other defects affecting the strength or appearance of the finished structure. All forms shall be free of bulge or warp or both. All forms shall be cleaned to the engineer's satisfaction before being used.

Only one type of form surface material shall be used in any form or group of forms for exposed concrete surfaces on similar parts of the structure.

Forms for re-entrant angles shall be filleted. All exposed corners and edges, with an enclosed angle of less than 120 degrees, shall be chamfered three-quarters of an inch unless otherwise required by the plans or as directed.

In designing forms and falsework, the concrete shall be treated as a liquid weighing at least 150 pounds per cubic foot for vertical loads and not less than 85 pounds per cubic foot for horizontal pressure. The design of the forms and false work system shall include allowances for temporary

construction loads. The rate of placement of concrete shall be so regulated that the pressures caused by the wet concrete will not exceed the designed form pressure. The unsupported length of wooden columns and compression members shall not exceed 30 times the diameter of the least side.

Some of the units of the structure may be required to be finished before other unit. Forms shall be designed for removal without disturbing adjacent forms. Form marks shall conform to the general lines of the structure. Column form marks may be horizontal or vertical or both but shall be made as symmetrical as practicable.

When directed by the engineer, openings shall be made in the forms at intervals that will permit ready access for form cleanout inspection, placement and compaction of the concrete. All extraneous matter, within the forms, shall be removed immediately before placing concrete. Cleanout ports shall be provided at the top surface of concrete, where a stoppage or placing occurs in narrow forms for walls or columns, or where the bottom of the form is inaccessible.

All forms shall be set and maintained in true alignment, grade and section until the concrete has sufficiently hardened. The interior surfaces of forms shall be adequately treated with an acceptable material to insure non-adhesion of mortar. All forms shall be mortar-tight. Wooden forms shall be thoroughly soaked with water if necessary to close cracks caused by shrinkage. Forms shall remain in place for periods specified in Article 41.04 (K). When forms appear to be unsatisfactory in any way, concrete placement shall be stopped until the defects have been corrected.

Metal tie rods or anchorages within the forms shall be fitted with suitable cones or comparable devices. Metal tie rods or anchorages shall be removed to a depth of one inch from the surface without injury to the concrete. All fittings for metal ties shall be of such design that upon their removal, the cavities which are left will be of the smallest possible size, but of sufficient diameter to allow the cavity to be "dry packed" with cement mortar. The cavities shall be filled with cement mortar and the surface left sound, smooth, even and closely matched to the color of the adjacent concrete.

(E) Placing Concrete.

(1). **General** Concrete shall be placed immediately after mixing. Concrete which has not been placed, within the time limits specified in Article 40, shall not be used.

When the high ambient temperatures for the day of concrete placement are expected to exceed 60° F., the contractor shall be required to use

an approved admixture for the sole purpose of retarding the initial set of all deck slab concrete. No reduction in cement content will be allowed for deck slab concrete by this requirement.

The temperature of mixed concrete, immediately before placing, shall be not less than 40°F., nor more than 90°F. Aggregates and mixing water shall be heated or cooled as necessary to produce concrete within these temperature limits.

When chutes, troughs or pipes are used as aids in placing concrete, they shall be placed and arranged in such a manner that the ingredients of the concrete are not separated.

The method of placing the concrete shall not be allowed to cause segregation of the aggregates or displacement of the reinforcement.

If segregation of the concrete ingredients occur, it may be necessary to equip chutes, troughs or similar devices with baffle boards or shorten their length and change the direction of the movement of concrete. All chutes, troughs and pipes shall be thoroughly cleaned by flushing with water after each run, as required. Water used for flushing shall be discharged away from the forms or the concrete in place. Open troughs and chutes shall be metal or metal lined and shall extend as close as possible to the point of deposit. A hopper or other device shall regulate the discharge when the discharge must be intermittent.

The concrete shall not be allowed to drop from a height of more than five feet except within a suitable conduit. At no time can the concrete be allowed to fall through or over reinforcing steel, tie rods or similar obstructions which could cause segregation of the ingredients of the concrete. Concrete shall not be deposited in a large quantity at any point and then worked or run along the forms as a substitute for placing it in its final position.

The use of aluminum pipe or chutes, troughs, and the like, lined with aluminum to place or transport concrete is prohibited. The use of mixers equipped with aluminum parts which come in contact with the concrete or concrete ingredients is also prohibited.

Special care shall be taken to fill each part of the forms by depositing concrete directly as near final position as possible, to work the coarser aggregates back from the face and to force the concrete under and around the reinforcement bars without displacing them. The placing of concrete shall be done in such manner that the steel reinforcing is not coated with cement before its final embedment. In depositing concrete around steel shapes and closely spaced reinforcing bars the concrete shall be deposited on one side of the steel and worked until it flushes under the steel to the opposite side before any concrete is placed on the opposite side or over

the steel. After the concrete has taken its initial set, care shall be exercised to avoid jarring the forms or placing any strain on the ends of projecting reinforcement.

Concrete shall be compacted by continuous working with suitable tools or suitable vibrating equipment in a manner acceptable to the engineer. All concrete, except handrails or concrete placed under water, shall be compacted by working with an internal vibratory tamper operating with a vibrating frequency of not less than 4,500 vibrations per minute. The vibrating element shall not be attached to, nor shall it be held against, the forms, reinforcing steel, or any other embedded fixtures around which the concrete is being placed. The vibrator shall be so operated that it will not penetrate through the fresh concrete into any partially hardened concrete. Vibration shall be supplemented by such spading as is necessary to insure smooth surfaces and dense concrete, along form surfaces and in locations impossible to reach with vibrators. The use of external form vibrators will be permitted only when requested in writing by the contractor and approved by the engineer.

All reinforcement, including dowels and other embedded items, shall be accurately placed as shown on the plans and shall be firmly held in position during concrete placement. All such material shall be thoroughly cleaned and substantially free from coatings of detrimental rust, scale, oil, dried mortar deposits, or any foreign matter prior to their embedment in the fresh concrete.

Concrete shall be placed in each section of the work in a continuous operation, working day and night if necessary, to avoid stoppage planes. It shall be deposited in horizontal layers when practicable, placing thin layers at first that can be thoroughly worked into intimate contact with the concrete beneath. The depth of layers used shall be such that the succeeding layer shall be placed before the previous layer has attained initial set. Each layer shall be compacted in a manner that will break up and obliterate any tendency to form a plane of separation between the layers. Bulkheads shall be placed as directed, if an emergency stops concrete placing before any section is completed. A construction joint is defined as any place where concrete placement has stopped and the concrete has taken its initial set. Construction joints shall meet the requirements of Article 41.04(G).

A construction joint at a location where a "feather edge" might be produced in the succeeding layer shall be formed by inset work. The succeeding layer shall end in a body of concrete having a thickness of not less than six inches.

The method of placing concrete shall be regulated to place all construc-

tion joints across regions of low shearing stress and in such locations as will be hidden from view to the greatest possible extent.

(2) Pumping Concrete. Placement of concrete by pumping will be permitted only if specified in the special provisions or if authorized by the engineer. The equipment shall be suitable in kind and adequate in capacity for the work and shall be so arranged that no vibrations result that might damage freshly placed concrete. The pump shall be operated to produce a continuous stream of concrete without air pockets. After pumping is completed and if the concrete remaining in the pipeline is to be used, it shall be ejected without contamination or separation of the ingredients. After ejection of concrete in the line, the entire equipment shall be thoroughly cleaned.

The use of aluminum pipe or pumping equipment with aluminum parts which will come into contact with the concrete or concrete ingredients is prohibited.

(3) Concrete Columns. Concrete shall be placed in one continuous operation, unless otherwise directed. Columns shall be allowed to set at least twelve hours before the caps are placed. No concrete shall be placed in the superstructure until column forms have been stripped sufficiently to determine character of concrete in the columns.

The load of the superstructure shall not be allowed to come upon the columns until such time as the strength of the concrete reaches 80 percent of the required 28-day compressive strength. This strength shall be determined using standard 6 in. x 12 in. test cylinders.

(4) Concrete Piling. Concrete piling shall meet the requirements of Section 46.

(5) Concrete Slab and Girder Spans. Slabs and girders having spans of 30 feet or less shall be placed in one continuous operation.

Girders spanning more than 30 feet may be placed in two operations. The first operation is placing of the girder stems to the bottom of the slab haunches. The second operation is placing the slab.

Shear keys shall be provided by inserting beveled timber blocks to a depth of at least 1½ inches in the fresh concrete at the top of each girder stem. A sufficient number of blocks shall be used to cover uniformly about one-half of top surface of the girder stem and the blocks shall be removed as soon as the concrete has set sufficiently to retain its shape.

The time period between placing the girder and placing the slab shall be at least 24 hours. Immediately before placing the slab, the contractor shall check all falsework for shrinkage and settlement and shall tighten all

wedges to insure minimum deflection of the stems due to the added weight of the slab.

Concrete, in girder haunches less than three feet in height shall be placed at the same time as that in the girder stem. Whenever any haunch or filler has a vertical height of three feet or more, the abutment or columns, the haunch, and the girder shall be placed in three successive stages: first, up to the lower side of the haunch; second, to the lower side of the girder; and third, to completion.

(F) Depositing Concrete Under Water. Concrete shall not be exposed to the action of water before setting, or deposited in water, except with the approval of the engineer. The method and manner of placing concrete under water shall be as hereinafter designated.

All concrete deposited under water shall be mixed in the proportions designated for Class "AS" or "DS" concrete.

Concrete deposited under water shall be carefully placed in a compact mass in its final position by means of a tremie or other approved methods and shall not be disturbed after being deposited. Special care shall be exercised to maintain still water at the point of deposit. Pumping will not be allowed within the cofferdam, while depositing concrete under water. Pumping to unwater the sealed cofferdam shall not commence until the seal concrete has set sufficiently to withstand the hydrostatic pressure. No concrete shall be placed in running water. All form work, designed to retain concrete under water, shall be water-tight. The method of depositing concrete shall be so regulated as to produce approximately horizontal surfaces. Each seal shall be placed in one continuous operation.

A tremie shall consist of a steel or other approved rigid tube having a diameter of not less than 10 inches, and be constructed in sections having flanged couplings fitted with gaskets. The means of supporting the tremie shall permit free movement of the discharge end over the entire top of the work and shall permit it to be lowered rapidly, when necessary to choke off or retard the flow.

The discharge end of the tremie shall be entirely sealed at all times and the tremie tube kept full to the bottom of the hopper. When a load is dumped into the hopper the tremie shall be slightly raised, but not out of the concrete at the bottom, until the load discharges to the bottom of the hopper. The flow is then stopped by lowering the tremie. The flow shall be continuous and in no case shall be interrupted until the work is completed. Particular attention shall be given to that portion of the top of the footing seal which constitutes a construction joint. That surface of the set concrete shall be prepared in accordance with Article 41.01 (G)

"Construction Joints", before attempting to join fresh concrete to the seal concrete.

(G) Construction Joints. The location of construction joints shall be planned in advance and shall be subject to approval by the engineer. When concrete placing is delayed and the concrete has taken initial set, the point of stopping shall be deemed a construction joint. The placing of concrete shall be carried continuously from joint to joint. These joints shall then be perpendicular to the principal lines of stress and in general be located at points of minimum shear.

At all horizontal construction joints and at other locations, when directed, a gage strip not less than two inches thick shall be placed inside the forms along all exposed faces to give the joints a straight line and eliminate wedge shaped particles of concrete that might chip off.

In joining fresh concrete to concrete that has already set, the forms shall be drawn tight against the face of the set concrete and all gage strips and key forms removed. All laitance, loose and foreign materials shall be removed from the surface of the set concrete by sandblasting, high pressure water cutting, light bush hammering or other approved method. This surface shall be drenched with water and kept saturated until the new concrete is placed. Immediately prior to placing the new concrete, the surface shall be thoroughly coated with a thin coating of neat cement or given such treatment as required by the plans or special provisions.

In order to bond successive courses, suitable keys shall be formed at the top of the upper layer of each day's work and at other levels where work is interrupted. These keys shall be formed by the insertion and subsequent removal of beveled wood strips. All construction joints shall be keyed or doveled as shown on the plans or as directed.

(H) Joints for Bridge Approach Slabs.

(1) Sealing Joints. Joints between structures and concrete approach slabs, and between concrete approach slabs and concrete pavement, shall be sealed in conformance with the details shown on the plans and the requirements of these provisions.

The completed sealed joints shall resist the intrusion of non-compressible material or other foreign matter into the joint and shall resist the infiltration of water into the joint.

(2) General. Forms for joints shall be so designed and constructed so that they may be removed without injuring the concrete.

Joints shall be covered or otherwise protected by the contractor to pre-

vent debris and foreign material from entering the joint prior to installing the seal.

Construction equipment and other vehicles operated directly across the joint shall be limited to rubber tired equipment.

All spalls, fractures, breaks or voids in the concrete surfaces of the joint shall be repaired by methods approved by the engineer.

Immediately prior to placing the seal, the joints shall be cleaned by abrasive blast cleaning or by other methods approved by the engineer and then cleaned with high pressure air jets to remove all residue and foreign material. Expansion joint filler shall be protected from the abrasive blast.

Joint surfaces shall be surface dry at the time the seal is placed.

(I) Cold Weather Concreting.

(1) General. The contractor shall assume all risk of placing concrete in cold weather. Placing concrete during freezing weather shall in no way relieve the contractor of the responsibility for proper results. Unsatisfactory concrete, placed under these conditions, shall be removed and replaced at the contractor's expense.

Before any concrete is placed, all ice, snow and frost shall be completely removed from within the formwork receiving the concrete. Concreting operations shall meet the following requirements when the ambient temperature falls below 40° F.

The contractor shall furnish recording thermometers with the range of 0° to 212° F when steam curing is used and within other approved ranges for conventional cold weather heating and curing. Temperatures shall be recorded automatically and continuously on a chart for periods not less than 24 hours. A sufficient number of recording thermometers shall be furnished as required to keep accurate records of curing temperatures but not less than one such thermometer per unit being cured. The contractor shall furnish and place sufficient other type thermometers as deemed necessary and at the locations designated by the engineer.

(2) Heating and Placing Concrete. The contractor shall furnish concrete that will have a temperature of at least 60° F and not more than 90° F at the time of placing.

Heating equipment shall heat the materials uniformly. Such heating shall preclude the occurrence of non-uniform moisture contents or contamination in the aggregates.

When aggregates, water, or both aggregates and water must be heated, the aggregates shall be heated by either steam or dry heat to a temperature of not less than 70° F and not more than 150° F. Aggregates shall be

heated in a manner such that frozen lumps, ice and snow are eliminated.

The water shall be heated to a temperature between 70° F and 150° F.

Neither salt nor chemical admixtures shall be added to the concrete to prevent freezing.

(3) Protection of Concrete. When the low temperatures during a 24-hour period are expected to drop to or below 35° F or the high temperatures of the day are expected to remain below 40° F, the contractor shall furnish sufficient canvas and a framework or other type of housing to enclose and protect the structure in such a way that the air surrounding the fresh concrete is kept at a temperature of not less than 60° F for a period of seven days after the concrete is placed: Or at 70° F for 72 hours after placement and at not less than 40° F for the remaining portion of the seven day curing period.

Substructure units constructed within walled cofferdams may be cured by a combination of artificial heat and flooding. When this method of cure is selected, an air temperature of not less than 70° F. shall be maintained on the entire unit being cured, for a period of 72 hours after concrete placement. Upon completion of the 72 hour period, the unit shall be flooded. Flood water to which the concrete will be exposed shall not be less than 35° F. The air temperature surrounding the exposed concrete shall then be maintained at not less than 40° F. for the remainder of the seven day cure period.

Footing concrete may be cured under water provided that the temperature of the water does not fall below 35° F and at least 12 inches of water is maintained over the concrete for a minimum of 10 days.

The seven day curing period is based on the use of standard Portland cement and a curing temperature of not less than 60° F.

All heating of the air surrounding the concrete shall preferably be done with steam or hot water.

When using any type of artificial heat, it will be necessary that the conditions set forth for curing in Section 40 are complied with.

Combustion heaters shall be blocked up off the surface of the concrete and vented to the outside of the enclosure to avoid surface carbonation. The maximum temperature anywhere within the enclosure shall not exceed 120°F. when the concrete is protected by means other than live steam which produces a natural water cure.

At the close of the curing period, the heat may be reduced to such an extent that the temperature inside the housing shall not decrease faster than 15° per hour until such time that the temperature inside the housing is the same as that outside. A sudden change of temperature shall be prevented.

(J) Curing Concrete. All newly placed concrete shall be cured in accordance with the provisions of Section 40 or as provided herein.

For formed surfaces, it is permissible to leave the forms in place for the complete curing period provided the forms are not released or loosened until a minimum of seven days of curing time have elapsed; however, in order to facilitate finishing, side forms on ornamental work, curbs, end posts, railings and parapets shall be removed in not less than 12 or more than 48 hours, depending on weather conditions.

(K) Removal of Forms and Falsework. Forms or falsework shall not be released, loosened or removed at any time without the consent of the engineer. Such consent shall not relieve the contractor of responsibility for the safety of work. Blocks and bracing shall be removed with the forms and in no case shall any portion of the wood forms be left in the concrete.

Forms for the various parts of the structure shall not be removed except under the following conditions: that the minimum number of days specified in the enclosed table have elapsed after placing the concrete; that the days specified in this table are exclusive of days when the ambient temperature falls below 40° F; that because the seven day curing period is based on curing temperature of not less than 60° F, the exact number of days shall be determined by the engineer and will be dependent on the curing conditions of the concrete at the site subsequent to placing the concrete; and that the contractor may request to use high-early strength cement or a richer mix to attain concrete compressive strengths earlier than the schedule shown in the table. Such requests shall be made in writing to the Construction Bureau.

ITEM	MINIMUM TIME
(a) Walls, piers and abutments (not yet supporting loads)	12 hours
(b) Sides of columns, beams and other comparable parts	12 hours
(c) Railings (Support Forms)	3 days
(d) Sidewalks on bridge	7 days

(Sidewalk forms shall, in all cases, be released before the main girder and slab forms are released).

(e) Slabs when supported on steel or wood stringers or precast concrete girders and whose unsupported span length is less than 10 feet...7 days

(f) Centering under cross-beams, girders, T-beams, caps, struts, box girders, top slabs on concrete box culverts and slabs14 days

Lips of mortar and all irregularities caused by form joints shall be removed. The presence of honeycomb areas may be cause for rejection of the structure, and upon written notice, the contractor shall remove and re-

build the structure in part or in whole as specified, at no cost to the Department of Highways.

As soon as forms are removed all projecting wires, tie bolts, and other metal form ties which pass through the body of the concrete shall be cut back as specified in part (D) of this Article. All holes thus formed and repairable honey-combed concrete in all parts of the work, and voids and depressions in exposed portions of the work shall be repaired as follows: All coarse or broken material shall be chipped away until a dense uniform surface of concrete exposing solid coarse aggregate is obtained. Feather edges shall be cut away to form faces perpendicular to the surface being patched. All surfaces of the cavity shall be thoroughly saturated with water, after which a thin layer of neat cement mortar shall be applied. The cavity shall then be filled with a thick mortar mixed in the same proportion as that which was used in the body of the work and of the same temperature as the surface against which it is to be placed. The cement used in the patching mortar for exposed areas shall be a blend of Portland cement and White Portland cement properly proportioned so that the final color of the cured mortar will be the same as the color of the surrounding concrete. The mortar shall be thoroughly tamped into place and the surface floated with a wood float before initial set takes place. The patch shall then be cured as set forth for the concrete in Section 40.

For patching large or deep areas, coarse aggregate shall be added to the patching material and special precautions shall be taken to insure a dense, well bonded and properly cured patch, all as required by the engineer.

All falsework piling shall be pulled or cut off one foot below finished ground line where conditions will permit. If conditions are not favorable for pulling or cutting off the piles as stated above, the piles shall be either broken or shot off at the stream bed, unless otherwise directed by the engineer.

(L) Finishing Concrete. All vertical concrete surfaces exposed in the completed work shall comply with the requirements of Ordinary Finish as specified in part (L) (1). The concrete bridge deck slab and the concrete curb and sidewalk surfaces shall comply with the requirements of parts (L) (5) and (L) (3) respectively, unless otherwise provided or indicated on the plans or in the special provisions.

(1) Ordinary Finish. An ordinary finish is defined as the concrete surface, left by the removal of the forms, after all holes caused by form ties, trapped air and all other defects are repaired. The finished surface shall be true and even, free from all stone pockets, depressions or projections beyond the surface.

An approved method used to obtain an ordinary finish is as follows:

(a) The surface of the concrete is first thoroughly soaked with water and a small amount of patching mortar mixed in the proportion described in Article 41.01 (K) worked into the small air holes and other crevices in the face of the concrete. This is done using a sponge float or wooden float.

(b) As soon as this mortar has taken a partial set, the excess is rubbed off using burlap or a piece of carpeting.

(c) Mortar that is allowed to set too hard shall be removed by rubbing the entire surface with a carborundum stone and water.

(d) All work shall be performed to the satisfaction of the engineer and the finished surface shall be of uniform texture and color.

All surfaces which cannot be repaired to the satisfaction of the engineer shall be given a "Rubbed Finish."

(2) Rubbed Finish. When the concrete has hardened before being rubbed, the surface shall be thoroughly saturated with water and rubbed with a medium coarse carborundum stone, using a small quantity of mortar on its face. Approved bonding agents may be used. The mortar shall be composed of cement and fine sand mixed in the proportions used in the concrete being rubbed. When forms are removed while the concrete is still "green," the surface shall be wetted and rubbed with a wooden float. If permitted by the engineer, a thin mortar proportioned as outlined above may be used in the rubbing.

Rubbing shall be continued until all form marks, projections and irregularities have been removed, all voids filled and a uniform surface has been obtained. The paste produced by this rubbing shall be kept moist and allowed to set for at least five days. The surface shall then be smoothed by rubbing with a fine carborundum stone and water. This rubbing shall be continued until the entire surface is of a smooth texture and uniform color. After the final rubbing is completed and the surface has dried, it shall be rubbed with burlap to remove loose powder. The finished surface shall be left free from all unsound patches, paste, powder and objectionable marks.

(3) Broomed Finish for Curbs and Sidewalks. The surface of concrete curbs and sidewalks shall be finished true to the lines and grades shown on the plans. Concrete shall be worked until the coarse aggregate is forced down into the body of the concrete and no coarse aggregate is exposed. The surface shall then be floated with a wooden float to a smooth and uniform surface. When the concrete in the curb or sidewalk has hardened sufficiently, the surface shall be given a broom finish. The broom

shall be of an approved type. The strokes shall be square across the curb or sidewalk from edge to edge with adjacent strokes overlapped. Strokes shall be made without tearing the concrete. The broomed finish shall produce regular corrugations not over one-eighth inch in depth.

(4) Special Tooled Finish. Special tooled finish shall be produced with a bushhammer, a pick, a crandall or other tool approved for this purpose. Air tools, preferably, shall be used. No tooling shall be done until the concrete has set for at least 7 days and as much longer as may be necessary to prevent the aggregate particles from being "picked" out of the surface. The finished surface shall show a grouping of broken aggregate particles in a matrix of mortar, each aggregate particle being in slight relief.

(5) Concrete Bridge Decks. Deck slabs and wearing surfaces shall be finished and straightedged as set forth below:

Deck slabs on multiple span structures and on single span structures greater than 70 feet in length and other wearing surfaces subject to highway traffic which are greater than 70 feet in length shall be finished by the machine method. All other deck slabs and wearing surfaces may be finished using either machine or hand methods.

After finishing by either the machine or hand method, the concrete surface shall be straightedged, given a broom finish and meet the completed surface requirements as set forth in paragraphs c, d and e below.

(a) Machine Method. A self-propelled finishing machine will be required for striking off and finishing the surface of the concrete. The Contractor shall furnish the Engineer with information as to the location and method of rail support, the size of rails and a detailed description of the finishing machine.

The finishing machine shall be operated over the full length of the bridge segment to be finished, prior to beginning concreting operations. This test run shall be made with the screed adjusted to its finishing position. The screed rails shall be adjusted for deflection and adjustments made to provide the proper cover on slab reinforcement and forms, during the test run. All necessary adjustments shall be made before concreting is begun.

As the concrete is placed, it shall be given as many passes of the screed as are required to obtain a smooth, even surface of the required crown and contour. A small uniform quantity of mortar shall be maintained ahead of the screed of the final pass. At no time shall the quantity of concrete carried ahead of the screed be so great as to cause slipping of the finishing machine wheels on the rails.

Unless otherwise approved by the Construction Bureau, the transverse axis of the finishing machine shall be oriented so that each pass of the strike-off will be along lines parallel to the centerline of bearing on all pre-stress girder and steel girder spans skewed more than 15° . The heading of concrete placement shall be maintained parallel to the heading of the strike-off to maintain nearly equal loads on each girder.

(b) Hand Method. After the concrete is placed, it shall be struck off with a template or a vibrating screed. Concrete shall be finished to an even surface by means of both longitudinal and transverse floats. The use of power trowels will not be permitted.

(c) Straightedging. A ten foot straightedge shall be used to cut high spots from the surface of the plastic concrete. A ten foot floating straight edge shall be used to remove any unevenness from the surface. A combination tool, which functions both as a straightedge for cutting and floating, is permitted.

The contractor shall test the concrete for the proper surface smoothness, with a ten foot straightedge, while the concrete is still plastic. The straightedge shall be held in contact with the surface in successive positions parallel to the center line and the whole area tested as necessary, from one side of the slab to the other. Advances along the surface shall be in successive stages of not more than one-half the length of the straightedge. Any depressions found shall be filled immediately with freshly mixed concrete, then struck off, consolidated and refinished. High areas shall be cut down and refinished. Straightedging and correction of surface irregularities shall be done from foot bridges resting on the side forms and spanning but not touching the concrete. Straightedge testing and surface corrections shall continue until the entire surface is free from observable departures from the straightedge and the slab conforms to the required grade and cross section.

(d) Broom Finish. A final pass of a ten foot straightedge float shall be made to seal the top surface of the plastic concrete before the broom finish is applied. When a transversely-broomed finish is used, the allowable variation noted herein shall be independent of the depth of the broom marks.

(e) Surface Smoothness. The finished surface shall be in substantial conformity with lines, grades, and cross-sections shown on the plans or as established by the engineer. The finished surface shall not vary more than one-eighth inch from a ten foot straightedge place parallel to the centerline of the roadway. High spot variations shall be measured as one-half the

distance between the end of the straightedge centered on the apex, with the opposite end held in contact with the surface. Low spot variations shall be measured as the distance from the straightedge to the surface with the straightedge centered on the low point. Unacceptable surface variations shall be corrected by grinding off high spots and patching or filling low areas.

All ground areas, except those where a grooved non-skid surface is left by diamond-faced saw type cutters, shall be sealed with an approved light colored low viscosity epoxy resin adhesive. In order to provide a non-skid surface, a medium silica sand shall be spread over the epoxy before it takes a set. Ground areas, including any buildup from sealing, shall meet surface variation requirements.

(6) Bridge Seats and Top of Walls. The concrete at bridge seats and the top of walls shall be brought to the required grade elevation, struck off with a straightedge and floated to a smooth uniform texture. The concrete surfaces in the area of bridge bearing assemblies shall be sloped slightly to drain water away from the bearing devices.

Bush hammering will be permitted but only as a means of leveling the concrete surface under the bearing plate and removing laitance, loose and foreign material. Bush hammering shall assure full level bearing. If necessary, steel shims shall be used to bring the masonry plates up to grade. Shims shall be the same size, except for thickness, as the masonry plate. The minimum thickness of any shim shall be one-eighth inch.

(M) Installation of Expansion or Contraction Joints. Expansion and contraction joints shall be located and formed as required on the plans.

(1) Open Joints. Open joints shall be constructed by insertion and subsequent removal of a template made of wood, metal or other approved material. The insertion and removal of the template shall be accomplished without chipping or breaking the corners of the concrete. Reinforcement shall not extend across an open joint unless so specified on the plans.

(2) Filled Joints. Poured expansion joints shall be constructed similar to open joints.

When premolded expansion joints are specified, the thickness of installed filler shall be as required on the plans. The joint filler shall be cut to the same shape and size as that of the surfaces to be joined. It shall be fixed firmly against the surface of the concrete already in place and shall not be displaced when concrete is deposited against it. Where necessary to use more than one piece of filler to cover any joint surface, the abutting

pieces shall be placed in close contact and the joint between them shall be covered with a layer of asphalt-saturated roofing felt. The roofing felt shall be at least 40-pound grade and have one side covered with hot asphalt. Immediately after the forms are removed, the filled joints shall be inspected carefully. All concrete or mortar that has sealed across the joint shall be cut neatly and removed. When, during construction, an opening appears in any deck slab joint, the opening shall be completely filled, as directed, with an approved tar or asphalt.

Necessary dowels, load-transfer devices, and other devices shall be placed as shown on the plans or directed by the engineer.

(3) Steel Joints. Plates, angles, or other structural shapes shall be accurately shaped at the shop to conform to the section of the concrete deck slab. The fabrication and painting shall conform to the requirement of the specifications covering those items. When called for on the plans or in the special provisions, the material shall be galvanized in lieu of painting. Care shall be taken to insure that the surface in the finished plane is true and free of warping.

Positive methods shall be used in placing the joint. Joints shall be kept in correct position during the placing of the concrete. The opening at expansion joints shall be made equivalent to that shown on the plans for normal temperatures. Care shall be taken to avoid impairment of the clearance in any manner.

(4) Water Stops. Metal or rubber water stops shall be placed as shown on the plans.

(N) Placing Anchor Bolts. Anchor bolt holes may be drilled or formed. Formed bolt holes shall be made by inserting, in the fresh concrete, surface treated wooden plugs, metal pipe sleeves or other approved devices which are withdrawn after the concrete has partially set. Drilled holes shall be at least one inch diameter larger than the size of the anchor bolts. To assure that the drilled holes are of adequate depth, the anchor bolts shall be dropped into and then removed from the dry holes before the beams are set. Holes of the correct depth shall be filled about two-thirds full of Portland cement grout and by a uniform, even pressure or by light blows with a hammer (flogging and ramming will not be permitted) the bolt shall be forced down until the grout rises to the top of the hole and the anchor bolt nut rests firmly against the metal shoe or pedestal. Formed bolt holes shall be at least three inches in diameter to allow for horizontal adjustment of the bolts. The exact location of the anchor bolts shall be determined and the anchor bolts grouted in the holes with Portland cement grout.

All excess grout shall be removed and the metal surfaces cleaned for painting.

Bolt holes into which the anchor bolts will not be grouted until after freezing weather shall be protected against damage from ice expansion by filling the holes with a non-evaporating anti-freeze solution of adequate strength to protect against freezing. Prior to grouting the bolts, the anti-freeze shall be removed, the holes thoroughly cleaned by flushing with clean water and the holes then filled with grout.

In lieu of the above specified methods, anchor bolts for simple spans may be set to exact location in fresh concrete. If this method is used, great care shall be exercised to insure the proper setting of the bolts. All inaccuracies which will be detrimental to the structure shall be corrected by approved methods:

(O) Setting Shoes and Bearing Plates. Shoes and bearing plates shall be set as provided in Section 43 and described under Article 41.04 (L) (6).

(P) Drainage Holes and Weep Holes. Drainage holes and weep holes shall be constructed in the manner and at the locations indicated on the plans or required by the engineer. Ports and vents for equalizing hydrostatic pressure shall be placed where required.

Forms for weep holes through concrete may be wood, clay pipe, asbestos-cement pipe, PVC pipe, concrete drain pipe, wooden boxes, or metal. Wooden forms, if used, shall be removed after the concrete is placed. Exposed surfaces of metal drains shall be painted or galvanized as indicated on the plans.

(Q) Pipes, Conduits and Ducts. Pipes, conduits or ducts that are to be encased in concrete shall be installed and rigidly braced before the concrete is placed. Pipes shall be held or braced rigidly during concrete placement, in order to prevent their displacement.

Lengths of three inch asbestos-cement pipe or approved equal, shall be furnished and installed in the bottom slab at the low point of each box girder cell, to provide drainage for each cell. The pipe shall extend one-quarter inch below the bottom of the slab but shall not protrude above the top surface of the slab.

(R) Loading of Piers and Abutments. No superstructure load shall be placed on finished bents, piers or abutments until the engineer so directs. The minimum time allowed before any superstructure load shall be placed on the substructure is seven days unless otherwise approved by the engineer.

(S) Opening to Traffic. Bridges with concrete decks shall be opened to traffic only after the approval of the engineer.

Concrete bridge decks shall remain closed to traffic, when the air temperature is 50° F. or higher, for the minimum length of time shown below. A longer time period will be required when the air temperature is lower than 50° F.

(1) 21 days after placing concrete containing normal Portland Cement.

(2) 7 days after placing concrete containing high-early-strength cement.

(3) Test results may indicate a longer time period is required than the minimum shown above.

(T) Defective Work. All defective work shall be repaired immediately or replaced. If the surface of the concrete is bulged, uneven, or shows honeycombing which, in the opinion of the engineer, cannot be repaired satisfactorily, the entire section shall be removed and replaced. The removal, repair, replacement, and all work involved to correct defective work will be performed at no cost to the Department of Highways.

41.05 METHOD OF MEASUREMENT. Except as otherwise provided in writing by the engineer, the cubic yards of concrete in structures will be computed in accordance with the dimensions shown on the plans.

The quantity of concrete involved in fillets, scoring and chamfers of two square inches or less in cross-sectional area will not be measured for payment.

No deduction will be made for the volume of concrete displaced by reinforcing steel, guard angles, pier nose angles, steel contraction joint assemblies, steel expansion joint assemblies, shear connectors, joint filler, drainage and weep holes, or pipes, conduits and ducts embedded in concrete.

Deduction will be made for the volume of concrete displaced by timber piles, concrete piles, steel piles, structural steel beams, girders and cover plates embedded in concrete. Deduction will also be made for the volume of concrete displaced by expansion joint openings at 60° F.

The volume of timber piles encased in concrete will be assumed as 0.8 cubic foot per linear foot of pile. No measurements or other allowances will be made for forms, falsework, cofferdams, pumping, bracing, and the like.

There will be no measurement for payment in the case of a lump sum bid.

The yardage of concrete measured for payment will not include any concrete contained in any other items when payment for the other items includes the concrete involved.

Class "F" concrete will not be measured for payment.

Excavation and backfill, reinforcement, miscellaneous iron and steel, waterproofing, piling, structural steel and such other items as may be included in concrete structures, will be measured as set forth in the various other sections of these specifications or as specified on the plans or in the special provisions.

41.06 BASIS OF PAYMENT. The volume of concrete in structures, determined as specified in Article 41.05 will be paid for at the unit price bid per cubic yard for the various types and classes as shown on the plans. The price and payment shall be full compensation for the concrete, for all materials including expansion joint filler, water stops and weep holes and conduits indicated on the plans, and for the installation of all joints, weep holes, drains, pipes and conduits and for all timber bumpers, forms, false-work, placing and finishing, bush hammering, shims, and for all labor, equipment, tools and incidentals necessary to complete the item, but will not constitute payment for reinforcing steel. Reinforcing steel will be paid for as a separate item.

The following percentages of the total quantity of the various classes of Concrete in place will be allowed for payment on progress estimates:

1. 80% when placed.
2. 85% when curing has been completed.
3. 95% when all finishing has been completed.
4. 100% when the unit area is cleaned up to the satisfaction of the engineer. (Each unit of the substructure shall be a unit area. The entire superstructure of each structure shall be a unit area).

If the item or items, was bid on a lump sum basis, the lump sum payment will include the same general provisions cited above.

Class "F" concrete is not payable directly, but shall be considered as a subsidiary obligation of the contractor, covered under the contract unit price for the individual work involved. The term Class "F" concrete shall be so interpreted as to include all materials, forms, steel, labor and any other costs involved in the completion of the item.

The cost of furnishing all materials, tools, equipment and labor necessary to construct the joints and seals for approach slabs shall be included in the unit price bid for Concrete Approach Slab.

SUB-SECTION 41.10. PROTECTIVE COATING FOR CONCRETE BRIDGE SUPERSTRUCTURES.

41.11 DESCRIPTION. This item shall consist of furnishing a protective coating for bridge decks, the top surfaces of sidewalks, and the tops and

inside vertical surfaces of curbs and end posts. The protective coating methods shall be in accordance with these specifications and within reasonably close conformity to the locations shown on the plans.

41.12 MATERIALS. Materials shall be as specified by Article M-340.08.

41.13 CONSTRUCTION REQUIREMENTS.

(A) Boiled Linseed Oil.

(1) Areas and Preparation. The concrete shall be 14 days old before application of boiled linseed oil protective coating. The protective coating shall be applied before traffic is allowed to use recently constructed structures.

The surface to be treated shall be dry and be thoroughly cleaned of all dirt, debris, oil, grime, grease, loose particles, and foreign matter which would prevent penetration, adhesion, or drying of the protective coating.

The concrete surface to be treated shall have at least a 48-hour drying period just prior to the application of the mixture.

All dust shall be removed, immediately before application of the protective coating, by an air blast directed over the surfaces to be treated.

(2) Application. The interior of application equipment shall be cleaned thoroughly before the protective coating is initially poured in.

Unless otherwise directed, the application shall be made during weather conditions suitable for drying and when the temperature of the concrete and air are 50°F. or higher at the time of application.

The rate of application shall be no more than 40 square yards per gallon of mixture for the first coat and no more than 60 square yards per gallon of mixture for the second coat.

The second application shall not be made until the concrete has regained its dry appearance; this is usually no less than 24 hours after the first application.

The protective coating shall be applied, as directed, by approved mechanical pressure spray equipment, by portable hand-spray equipment, or a combination of these methods. The spray nozzle shall be within 18" of the surface or as directed. Equipment or methods that do not provide complete and uniform coverage, at the rate specified, shall be replaced or otherwise corrected.

When the initial application is made on concrete surfaces carrying traffic, these surfaces shall be closed to traffic for a period of not less than 4 hours, or longer if necessary, until penetration is complete and all tackiness of the coating has disappeared.

(3) Safety Precautions. Every precaution shall be taken to protect traffic, workmen, and the concrete surface against the occurrence of fire. Traffic shall be prohibited from the area until the concrete has regained its dry appearance.

CAUTION! Flammable and volatile mineral spirits are blended into the protective coating. Fire of any sort, including open flames, sparks or lit cigarettes, shall be carefully guarded against.

(B) Water Soluble Liquid Membrane Compound. Preparation and application shall be as prescribed in Article 40.05 (E) (3).

41.14 METHOD OF MEASUREMENT. The Protective Coat will be measured in square yards of surface area upon which it has been applied as specified.

41.15 BASIS OF PAYMENT. Protective Coating will be paid for at the contract unit price per square yard of Protective Coat which price and payment will be for two applications of Boiled Linseed Oil or one application of Water Soluble Liquid Membrane Compound, complete in place as specified.

SECTION 42

PRESTRESSED CONCRETE

MEMBERS

42.01 DESCRIPTION. This work shall consist of furnishing and placing precast prestressed concrete members in accordance with the details shown on the plans, and as specified in these specifications and the special provisions.

The work shall include the manufacture, transportation, and storage of beams, slabs, piling, and other structural members of precast prestressed concrete. It shall also include the placing of all precast prestressed concrete members, except piling which shall be placed as provided in Section 46, "Piling".

The members shall be furnished complete including all concrete, prestressing steel, bar reinforcing steel, and incidental materials.

42.02 PRESTRESSING METHODS Prestressing shall be performed by pretensioning or post-tensioning methods. The method of prestressing, shall be optional with the contractor, subject to the requirements specified.

42.03 FABRICATION DRAWINGS Prior to casting, the contractor shall submit to the engineer for approval, fabrication drawings which show complete details of method, materials, and equipment he proposes to use in the prestressing operation.

The fabrication drawings shall include the following information:

- (1) An erection layout of the members to be placed in the structure or structures with a production number assigned to each prestressed member. The completed member shall be marked with this number.
- (2) The tentative fabrication schedule shall be noted at the time fabrication drawings are submitted for approval.
- (3) The mix design proposed for use in production as well as concrete admixtures that will be used.
- (4) The name of the manufacturer of the prestressing steel and the specifications pertaining thereto.
- (5) An outline of the method and sequence of stressing showing a numbered or lettered layout to be followed to properly stress the member.
- (6) Complete details, including anticipated camber, tensioning forces

(initial and final), and required concrete strengths (transfer and 28-day).

(7) A complete detensioning procedure for the various castings for the project.

(8) Items incorporated into the beam, such as chairs, inserts, hold-downs, etc., shall be clearly shown, listed by source, type, size or capacity and supplier.

(9) All items incidental to the beams, such as bearing plates, rocker assemblies, anchor bolts, etc., shall be shown if supplied by the beam fabricator.

All other information and data necessary for the fabrication of the prestressed member shall be shown. Working drawings shall clearly indicate any deviation from the prestressed concrete beam details shown on the plan drawings.

Design calculations to support the system and method of prestressing proposed in production shall be submitted. Calculations may be on standard 8½" x 11" sheets.

The contractor shall furnish prints of the fabrication drawings, in quadruplicate, for approval. After approval, he shall furnish three or more prints, as required, of the approved drawings. All fabrication drawings shall be 22" x 36" with a 1½" margin on the left side and ½" margin on the other three sides.

Fabrication shall not begin until the working drawings have been approved and the plant inspector has received approved prints thereof. No deviation from the approved plans shall be permitted without a written order.

42.04 MATERIALS.

(A) Concrete.

(1) **Cement, Air Entraining Agents and Admixtures:** These materials shall meet the requirements of Section 40, Articles 40.04(A)(1), (2) and (3), except that no admixture shall be used without written approval.

(2) **Water:** All water used in concrete for prestressed products shall meet the requirements of Article 40.04(B).

(3) **Aggregates:** Aggregates for prestressed concrete products shall meet the requirements of Section 100, Article M-100.01(A) and (B).

(4) **Design of Concrete Mixtures:** The concrete for prestressed girders shall have a minimum ultimate compressive strength of 4000 psi at transfer of prestress and 5000 psi at age 28 days. These strengths are the minimum required and will vary with beam design. The fabrication

drawings shall show the actual compressive strengths required for each project and the various beams fabricated therefore. It shall be the responsibility of the contractor to furnish a concrete mix design which will produce concrete capable of achieving the required compressive strengths. In lieu of the mix design responsibility, the contractor may request that a mix design be furnished by the Helena Materials Bureau; however, this will in no way relieve him of the responsibility of providing concrete meeting the requirements of these specifications. In any case, the mix design shall be submitted for review by the Materials Bureau prior to its use. Deviation from the established mix design will be permitted during fabrication only upon written receipt of adequate justification for the change.

The concrete shall be designed to contain not less than 6.5 sacks nor more than 8.0 sacks of cement per cubic yard of concrete. The slump range of class "Pre" concrete shall be established by the contractor within the limits of a 1" minimum to a 4½" maximum. The high and low limits of the range established shall not exceed 1½" of slump. The concrete shall be uniform in consistency and shall be readily workable for the equipment and operation proposed. The established slump range shall not be varied except as approved by the Materials Bureau.

(B) Reinforcing Steel. Bar reinforcement shall meet the applicable requirements of Section 47 and M-290. Reinforcing steel for prestressed members shall be of the deformed type and shall conform to the requirements of ASTM Designation A-615 Grade 40 or Grade 60, unless otherwise approved. Substitution of grades of bar reinforcing will be by written approval only.

Details of bar reinforcing as shown on the shop drawings shall reflect the following note: "All dimensions are out to out," or other applicable notation.

Rods used as dowels may be commercial quality mild steel. Bolts shall conform to the requirements of Section M-290, Article M-290.07.

(C) Prestressing Steel. High tensile wire prestressing steel shall conform to ASTM A-416 except as noted on the plans.

Typical load-elongation curves shall be furnished by the manufacturer of the strand for each individual shipment of prestressing steel to the fabrication plant. One certified copy of the load-elongation curve shall be delivered to the plant inspector.

All prestressing steel shall be protected against physical damage and shall be protected from rust and corrosion from time of manufacture until encasement in concrete. The use of strands with kinks, bends, nicks,

broken wires or other defects including loose rust shall not be permitted. All strand shall be carefully and thoroughly cleaned when necessary prior to being enclosed in the forms.

Strand in storage in the casting yard shall be blocked up off the ground and covered with water-proof coverings until used in production.

(D) Enclosures. Enclosures for prestressed reinforcement shall be accurately placed at locations shown on the plans or approved by the engineer.

All enclosures shall be metallic and shall be mortar-tight, with the exception that the contractor, at his option, may form the enclosures by means of cores or ducts composed of rubber or other suitable material which can be removed prior to installing the prestressing reinforcement. Enclosures made of aluminum shall not be used. Enclosures shall be strong enough to maintain their shape under such forces as will come upon them. They shall be one-quarter inch larger in internal diameter than the bar, cable, strand, or group of wires which they enclose. Where pressure grouting is specified, cores or ducts shall be provided with pipes or other suitable connections for the injection of grout after the prestressing operations have been completed.

(E) Structural Steel. Structural steel shall meet the applicable requirements of Section M-290.

42.05 CONSTRUCTION METHODS.

(A) General. Unless otherwise approved, the contractor shall certify that a technician skilled in the prestressing method to be used will be available to the contractor to give as much aid and instruction in the use of the prestressing equipment and installation of materials as may be necessary to obtain satisfactory results.

Deviations from approved prestressing details will not be permitted unless details of such deviations are submitted for approval in advance of use. Approval of any proposed method, materials or equipment shall not be construed as relieving the contractor in any respect, of full responsibility for satisfactorily completing the prestressing operations in accordance with the requirements of the plans and these specifications.

Safety measures must be taken by the contractor to prevent accidents due to possible breaking of the prestressing steel or the slipping of the grips during the prestressing process.

(B) Casting Yard. The precasting of prestressed concrete struc-

tural members may be done at any location selected by the contractor, subject to approval.

Before any site on State property is approved for use as a casting yard, the contractor shall submit to the engineer a plan of operation showing anticipated leveling or altering of the selected area. Upon completion of the work, the site shall be cleared of equipment and rubbish and restored as nearly as possible to its original condition.

(C) Forms. All side and bottom forms shall be constructed of steel. End bulkhead forms may be of steel or plywood.

Forms shall be of sufficient thickness, supported by adequate external bracing and stiffeners and shall be well-anchored so as to withstand the forces due to placement and vibration of the concrete. Form joints shall be tight enough to prevent loss of mortar. All points of strand exit through bulkhead forms shall be constructed and fitted to prevent mortar loss.

Grade and alignment shall be checked on side forms prior to each casting. Beam beds shall be checked for alignment at sufficient intervals to insure against gradual accumulative displacement. Beam bed forms shall be constructed and maintained to present not more than one-quarter inch deviation from a straight line in any 50 foot length of the bed.

Steel forms shall be maintained free from warp, bulge and other defects which detract from the appearance of the finished member. Where sections of forms are joined, an offset not to exceed one-sixteenth inch will be permitted. Forms shall be free from rust, grease, dried mortar coatings and other foreign materials. All forms shall be cleaned thoroughly and the facing shall be treated with a bond breaker coating prior to each casting. Form treating materials which stain or react with concrete will not be permitted. The application of form oil or other bond breaker materials shall be accomplished using such protecting measures necessary to insure against contamination of prestress strand and bar reinforcing. Soiled strand or reinforcing shall be cleaned with a non-contaminating solvent.

With the exception of the top of the beam, all exposed edges of concrete with an enclosed angle of less than 120 degrees shall be chamfered. Chamfer strips shall be free from irregularities and all joints shall be smooth with the chamfer tightly fitted against abutting forms.

Forms shall be fitted with a grade strip or other approved positive control for establishing the nominal depth of the beam.

Forms shall be constructed to permit removal from the member without damage to the concrete.

If the dimensions of the forms proposed for use in production vary from

the beam section dimensions shown on the plans, such variations shall be shown on the fabrication drawings.

(D) Placing Reinforcing Steel. All bar reinforcing steel shall be accurately placed in the positions shown on the plans and firmly held during the placing and setting of concrete.

Bars shall be fastened at all intersections of adjacent bars regardless of the spacing.

Tack welding of reinforcing steel in lieu of standard wire ties will not be permitted when the reinforcing bar is a stress carrying member. Welding of non-stress reinforcing bars will be permitted only by written prior approval. Details of the tack welding procedure shall be shown on the fabrication drawings. The welding of reinforcing steel other than shown on the approved tacking detail or fabrication drawings will not be permitted. The fabricator may, for his own convenience, tie in additional reinforcing bars to which inserts, void ducts, etc., may be secured by tack welding. When this method of securing embedded items is selected, the tensioned strand shall be protected from weld spatter by covering with set burlap or other satisfactory protective covering.

Distance from side forms shall be maintained by stays, ties, or approved metal chairs. The use of precast mortar blocks, pebbles, pieces of broken stone or brick, metal pipe or wooden blocks will not be permitted.

The required clearance between the beam stirrups and the beam bed shall be maintained through the use of metal chair supports with stainless steel or other approved corrosion resistant legs. Bar reinforcing in the ends of prestressed beams shall be designed to provide adequate clearance for placement of paving notch blockout, void ducts, embedded plates and anchorages, inserts and the like without interference with the design spacing of the reinforcement.

Reinforcement in the prestressed member shall be inspected in place and approved by the inspector before the placing of concrete begins. Concrete placed in violation of this provision may be rejected.

(E) Prestressing Equipment. The contractor shall provide all equipment necessary for the prestressing of concrete members. Prestressing shall be accomplished with approved jacking equipment. If hydraulic jacks are used, they shall be equipped with accurate pressure gauges. The combination of jack and gauge shall be calibrated as a unit by a qualified testing laboratory. The jack and gauge unit shall be calibrated with the cylinder extension in the approximate position that it will be in at the final jacking force. The unit shall be accompanied by a certified calibration chart. If other types of jacks are used, proving rings or other ap-

proved devices calibrated by a qualified testing laboratory shall be furnished so that the jacking forces may be accurately determined. Calibration of jacking equipment shall be repeated at intervals not to exceed one year and after each repair. Recalibration may be required at any time if, during progress of the work, any jack or gauge appears to be giving erratic results or if the gauge reading and elongations indicate materially different stresses.

A tensioning system that utilizes hydraulic gauges shall be designed so that the gauge pointer will remain steady and not fluctuate until the jacking load is released from the tendon. The gauge shall be capable of reading loads directly in pounds or shall be accompanied by a chart from which the dial reading can be converted into pounds. The readings of the gauging system shall be maintained within an accuracy of two percent. The position of the gauging equipment shall be arranged such that the plant inspector can observe elongation measurements and gauge reading from one position. Gauges shall have a reading dial of sufficient size to be graduated to read in increments not to exceed 100 pounds pressure. The range of the gauge or of load cells when used, shall be such that the lowest ten percent of the manufacturer's rated capacity will not be used in determining the jacking stress unless calibration data establishes consistent accuracy within the 2% requirement at the lower range.

End anchorages and stressing blocks for prestressed members shall be adequately designed to withstand the forces they will be subjected to during the prestressing operations. They shall be capable of maintaining the prescribed tension in all prestressed tendons in any member until the concrete has been placed and attained transfer strength. The end anchorage and stressing block shall be provided with an approved means of detecting significant movement or deflection during the prestressing operation. These checks shall be made at frequencies to be determined by the inspector.

The contractor shall provide equipment for determination of compressive strengths of concrete at or reasonably near the location of manufacture of the prestressed members. The test machine may be of any mechanical or hydraulic type capable of applying and measuring the required load. The percentage of error for loads within the loading range of the testing machine shall not exceed $\pm 1.5\%$. A certified calibration diagram shall accompany the machine at all times. The indicated load of a testing machine need not be corrected either by calculation or by the use of a calibration diagram to obtain values when such values are within the required permissible variation of $\pm 1.5\%$.

Testing machines for determination of concrete strength shall be veri-

fied at intervals not to exceed two years. Testing machines shall, however, be verified immediately after repair or adjustment of the weighing mechanism, after the machine has been moved (if not portable) and whenever there is reason to doubt the accuracy of the results, without regard to the time interval since the last verification. Calibration charts shall accurately cover the entire range of use proposed for the equipment.

(F) Pretensioning. The prestressing elements shall be accurately held in position and stressed by jacks. A record shall be kept of the jacking force and the elongations produced thereby. Several units may be cast in one continuous line and stressed at one time. Sufficient space shall be left between the ends of units to permit access for cutting of the strands after the concrete has attained the required released strength.

Unless an alternate method of strand tensioning is approved, strands shall be stressed to the total tension required by means of hydraulic jacks equipped with a gauge or a load cell or both.

Strand may be furnished in coils, reel-less packs or on reels. Stringing may be accomplished by pulling the strand singly or in multiples. Provision shall be made to relieve the effects of strand rotation when pulling from coils or reel-less packs.

Stringing of strand which would incorporate points previously gripped within lengths to be stressed shall not be permitted.

All tendons to be prestressed shall be brought to a uniform initial tension as shown on the approved fabrication drawings. Initial tension shall be the minimum force necessary to equalize stresses and eliminate slack in the strand and should generally fall within the range of 1000 to 3000 pounds.

The initial load may be applied by the same jack used for single strand tensioning, by fence stretchers and measured with a dynamometer, by dead weight, or by any other method which will provide a definite, uniform load providing such method is approved by the Bridge Design Section. Regardless of the method used, the initial load shall be measured within a tolerance of ± 100 pounds. Elongation measurements shall be computed for initial tensioning but shall not be used as a measurement of the initial force.

Upon completion of initial tensioning, the strand shall be marked with a reference satisfactory to the inspector. The reference shall provide for accurate measurement of elongation by final tensioning.

The induced stress shall be measured by elongation of the strands and checked by gauge pressure, load cell or both. The results shall agree within five percent. In no case shall the jacking stress exceed 75

percent of the specified minimum ultimate tensile strength of the prestressing steel. The elongation of the strands shall be measured to an accuracy of one percent of the theoretical elongation or one-eighth of an inch, whichever is smaller. In the event of apparent discrepancies between measured elongations and gauging measurements in excess of five percent, the entire operation shall be carefully checked and the source of error determined and corrected before proceeding further. Special attention shall be given to the condition of uplift devices, hold-down devices and strand openings in end bulkheads. These items shall be constructed and maintained to provide rounded, smooth surfaces at all points of contact with the strand.

Gauge readings, elongation measurements and calculations for elongation shall be made by the contractor and shall include appropriate allowances for operational losses peculiar to the tensioning system used. These allowances will include losses for strand slippage, movement of anchorages, friction, strand rotation and other forces acting on the strand. When variations in temperature between the strand at time of tensioning and the concrete at time of placement exceeds 30°F, appropriate corrections shall be applied to the computed elongation measurements.

The calculations for elongation shall be carefully reviewed by fabrication and inspection personnel at the beginning of production to insure the inclusion of all appropriate allowances required for the particular method of tensioning and existing conditions.

(1) Final Tensioning

(a) Single Strand Tensioning: After the initial load has been applied and the reference marks for use in determining elongation have been established, the strands shall be individually pulled to the final load. Each strand shall be tensioned to the load required as indicated by elongation measurement. The hydraulic gauge reading shall agree within five percent of the load indicated by the elongation measurement. If the load determined by elongation measurement does not agree with that indicated by the gauge within the required tolerance, the tensioning operation shall be discontinued and the bed inspected for restrictions that may be affecting the accuracy of the applied load. Such factors may include strand slippage at the dead end anchor, misalignment of the jacking ram, restrictions at bulkheads, hold-up trees, deflection devices, etc. If no discrepancies are found three more strands may be tensioned. If elongation measurement and gauge readings are in agreement within the required tolerance, the system shall be considered operative and acceptable. Because some variation in the modulus of elasticity and the cross

sectional area of a strand does exist, the tensioning of the strand in question may be accepted provided the difference between the load determined by elongation and that indicated by the gauge does not exceed six percent. No more than ten percent of the total number of straight strands for any one line of casting shall be accepted on the above basis.

If the difference between the loads determined by elongation and gauge readings exceed the tolerance limit, tensioning shall be discontinued and the source of the problem shall be determined and corrected.

(b) Multiple Strand Tensioning: After each strand has been preloaded and seated in the anchorage it shall be marked at both end anchorages for determination of elongation and slippage. References shall be established by the inspector from which parallel movement can be verified by equal measurement of movement on opposite sides of the anchorage.

The stressing force shall be measured by elongation and checked by the gauging system. In order to further verify the application of the design load and for checking the uniformity of pull, two load cells shall be used. One load cell shall be placed on each side of the line of pull and preferably on the outermost strands of an upper row of straight strands.

If hydraulic gauge and the load cells agree with the load determined by the elongation measurements within five percent, the strands shall be considered properly tensioned.

If the gauge reading is within five percent but either or both of the load cells exceed that limit indicating eccentricity of pull, the strands shall be retensioned including preloading. The load cells shall be relocated and placed on the strands nearest to those previously gauged.

If upon retensioning, the load cells are within the five percent tolerance and no excess slippage of strands has occurred and the movable anchorage has traveled the required distance, the tensioning may be accepted.

If the difference between the loads determined by elongation, gauge and load cell readings exceeds the tolerance limit, tensioning shall be discontinued and the source of the problem shall be determined and corrected. In order to minimize friction, the jacking ram or rams, guide rods and movable anchorage rails shall be well-lubricated and the ram shall be run through its length of travel several times prior to tensioning the strand.

(c) Tensioning Draped Strands: The fabrication drawings submitted for approval shall show clear and complete details of the

method proposed for tensioning the draped strands. These details shall include gauge and elongation readings for initial, intermediate and final tensioning, as well as the deflecting sequence where applicable, for the method used.

Draped pretensioned strands may be tensioned by partially jacking at the stressing block and subsequent depressing or up-lifting to the deflected position or by tensioning to the initial and final loads with the tendons held in their final design position by means of pins, rollers or other approved methods. Low friction devices shall be used at all points of slope change of the draped strand regardless of the method used.

When draped strands are partially tensioned in the straight condition and subsequently depressed to their final design position, determination of the final load shall be made in accordance with the following requirements.

Prior to beginning the tensioning operation a load cell shall be placed on one of the strands to be deflected, at the dead end anchorage, in each line of beams to be cast. The inspector shall select the strand upon which the load cell is to be placed. Upon completion of tensioning, the load cell reading shall indicate within six percent the final design load of the draped strand.

In the event the load cell reading exceeds the allowable tolerance, the contractor shall utilize additional deflecting jacks to distribute friction and restraint at the deflecting points or if necessary, the entire method shall be revised to provide for application of the final design load within the tolerance set forth herein.

If the tensioning of draped strands consistently indicates readings within the allowable limit, the inspector may reduce the requirement for use of the load cell to every third line of beams for the same bed and the same layout.

If tensioning of the draped strand is to be accomplished by partial tensioning and up-lift or by tensioning in the draped position, the method shall be submitted to the Bridge Design Section, for approval prior to its use in fabrication.

The splicing of strand using suitable devices will be permitted. Only one splice shall be allowed on any one strand between anchorage.

Splices shall be located such that they will not fall within a beam. In the case of single strand tensioning the number of strands that may be spliced is not restricted. When multiple strand tensioning is employed, the number of strands spliced shall not exceed ten percent of the total number of strands in the casting line or all of the strands shall be spliced.

Strands from only one manufacturer shall be used in any one tensioning

operation. Care shall be taken that the direction of twist of strand wires is the same in all spliced strands.

The failure of one wire in a seven wire strand will be allowed to remain in the casting provided it falls within the limits set forth hereafter. For beams with:

Less than 20 strands, no wire breaks permitted.

20 to 39 strands, 1 wire break permitted.

40 to 59 strands, 2 wire breaks permitted.

60 or more strands, 3 wire breaks permitted.

The occurrence of more than the permissible number of wire breaks or more than one broken wire in any individual strand will require that the strand or strands be removed and replaced.

Any wire breaks that are permitted to remain in the casting shall be located and the broken ends shall be securely wrapped with tie wire to prevent unraveling.

When ordered by the inspector, prestressing steel in a pretensioned member shall be checked by the contractor for loss of prestress not more than three hours prior to placing concrete. The method of checking for loss of prestress shall be approved by the inspector. All strands which show a loss of prestress in excess of three percent shall be retensioned to the original computed jacking stress.

Except as permitted in Article 42.05(D), the contractor shall not weld, flame cut or ground welding equipment to the bed or forms after tensioning of the prestressed strand has been completed.

(G) Placing Concrete

(1) General. Concrete materials shall be batched and measured as set forth in Section 40, Article 40.05(A), (1), (2) and (3), except as otherwise provided for in this section.

It shall be the responsibility of the contractor to measure the batch quantity of each ingredient, including all water, to provide a mix that conforms to the requirements of the plans, specifications and special provisions. Master batch sheets, when compiled by the fabricator, shall be checked for accuracy by the inspector prior to their use in production.

Mixing and mixing equipment shall comply with the applicable requirements of Section 40, Article 40.05(C)(1), (3), (4), (5) and (6). A time device for the purpose of locking the discharge gates of a stationary mixer will not be required; however, the mixer shall not be emptied until the materials have been mixed the specified time. Ready-mix delivery slips will not be required unless specifically requested by the inspector.

The batching operation and equipment shall be subject to inspection by

the plant inspector at all times. Non-compliance with approved procedures and equipment shall be cause for suspension of work pending satisfactory remedial action.

(2) Method and Manner The placement of concrete shall conform to the requirements of Section 41, Article 41.04(E)(1), except as otherwise provided for in this section.

Concrete shall be placed in a manner that will avoid segregation of aggregates and displacement of reinforcing steel, prestressing steel, conduit, void ducts and other embedded items. Concrete shall be deposited as near as possible in its final position in the forms. Depositing large quantities of concrete at one location and working it along the forms with vibratory equipment will not be permitted.

Placement of concrete in large members shall be subject to the approval of the plant inspector depending on the appearance of the unfinished members of the first casting. Concrete may be placed in the member in one lift where satisfactory results can be obtained or it may be required that it be placed in multiple horizontal lifts. When placed according to the latter method, placement shall be regulated to prevent the formation of cold joints. If delays are encountered whereby a cold joint is formed in the member, the concrete shall be rejected, removed and replaced. When layer placed, the first lift of concrete shall fill the forms to a point slightly above the juncture of the bottom flange and the beam web.

Concrete shall be compacted immediately after placement by continuous working with approved high frequency mechanical vibrators operating at not less than 4500 impulses per minute. Vibration shall be accomplished internally, externally or by a combination of both methods to insure the flushing of mortar to the surface of the forms. Vibration of succeeding layers of concrete shall extend into the previously placed layer. Vibration shall be sufficient to thoroughly consolidate the concrete to a plastic mass but shall not be of such duration as to result in segregation. Vibrator heads shall not be held against the reinforcing steel, prestressing steel or other embedded items as an aid to accomplish consolidation. Internal vibrators shall be slowly inserted and removed from the concrete in order to prevent the formation of voids.

In addition to the vibrators normally used in the operation, one additional vibrator shall be available at the site, at all times during concrete placement.

(3) Concreting During Adverse Weather Conditions. Concrete operations carried on when the ambient air temperature falls below 40°F

shall comply with the requirements of Section 41, Article 41.01(I)(1) and (2).

When the ambient temperature prior to placement of concrete is 35°F or less, forms shall be preheated to 70°F plus or minus 20°F, for a period of not less than one hour to placement of concrete. When concrete is to be placed during hot weather, suitable precautions shall be taken to insure concrete temperatures which will not exceed 90°F at the time of placement. Under conditions of wind, humidity and heat that would lend to slump loss or premature drying during transport to the forms, open buckets shall be covered with wet burlap mats or other satisfactory coverings.

(H) Curing. Careful attention shall be given to the curing of concrete. The method of curing and the curing equipment shall fulfill the requirements of these specifications. Inadequate facilities, enclosures or lack of attention to proper curing of the concrete shall be cause for suspension of the work pending approved remedial action.

Precast prestressed concrete members shall be cured in accordance with Article 40.05(E) and (E) (1), or by steam curing, at the option of the contractor. When water curing is selected as the medium, protection of the concrete shall comply with the requirements of Article 41.04(I)(3).

Curing using the elevated temperature steam process shall conform to the following provisions:

The casting bed for steam cured members shall be completely enclosed or covered by curing blankets or other satisfactory flexible coverings. The enclosure or coverings shall be placed in such a manner so as to provide a minimum of six inches of clear air space between the cover and all surfaces of the concrete to be cured.

Flexible coverings shall be well anchored and kept in such repair so as to prevent loss of moisture. It is essential that moisture in the member be retained until the curing cycle has begun. Sufficient moisture shall be provided prior to commencing with the curing cycle to allow for uninterrupted hydration of cement and to prevent formation of surface cracks due to rapid loss of water while the concrete is plastic. Steam may be introduced prior to beginning the cure cycle to the extent that temperatures within the enclosure are maintained between 50° and 70°F. To prevent moisture loss during the three hour period prior to beginning the cure cycle, the top surface of the member shall be fog sprayed or covered with wet blankets as soon as possible after placement of concrete.

The steam cure cycle shall not commence until the concrete has been in

place a minimum of three hours. Steam shall be at 100 percent relative humidity and shall be applied in such a manner so as not to impinge directly on the surface of the concrete, forms or tendons. The ambient temperature within the enclosure shall be raised at a rate not to exceed 40°F per hour until a maximum temperature of from 140° to 160°F is reached. This temperature shall be maintained until the concrete has attained the strength required for transfer of prestress.

Upon completion of the cure cycle the beam shall be cooled gradually by decreasing the temperature within the enclosure at a rate not to exceed 40°F per hour until the temperature differential between the inside air and outside air does not exceed 25°F except as otherwise approved by the Construction Bureau.

A curing time-temperature record shall be maintained for each placement of concrete in the casting bed. The fabricator shall provide one automatic temperature recording thermometer for each 200 feet or fraction thereof, of continuous bed length in use. The recording thermometer shall continuously record curing temperatures throughout the full curing cycle. Temperature sensors shall be placed at locations satisfactory to the inspector as those being representative of the temperatures within the enclosure. Automatic recording thermometers shall be supplemented by as many standard bulb type thermometers placed at such locations as deemed necessary by the inspector. The accuracy of automatic recorders shall be certified once every twelve months or when there is reason to doubt the accuracy of the device. Steam curing shall not be permitted without automatic recorders.

Side forms may be removed from a member at the discretion of the fabricator. The fabricator shall assume all responsibility for determination of concrete strength when forms are removed prior to break of the release cylinders. Physical damage to the concrete resulting from early form removal shall be cause for rejection of the member.

The cure cycle may be interrupted for form removal; however, such interruptions shall not exceed 20 minutes on any member.

No member shall be exposed to below freezing temperatures until at least six days after casting.

If the fabricator elects to cure by other methods, the details thereof shall be submitted to the Construction Bureau for approval prior to use of the method.

(I) Transfer of Prestress. Prestress strands shall not be released until the concrete has reached the minimum compressive strength required for transfer of prestress. Release of the strand shall be accom-

plished immediately upon completion of the cure cycle, attainment of satisfactory release strength, removal of restrictive forms and while the concrete is still warm and moist. If a delay is anticipated, the temperature within the curing enclosure shall be maintained at not less than 50°F until transfer of prestress.

It shall be the responsibility of the contractor to determine whether or not the use of positive external hold-downs or weights will be required to offset the up-lifting forces in the member upon release of the hold-down strands. A note shall be shown on the fabrication drawings covering details of external weights or hold-downs when required. When weights are not required, the note shall so stipulate.

The method and sequence of releasing harped and straight strands shall be accomplished in such a manner that lateral eccentricity of prestress will be held to a minimum. Details of release of bed and the strand cutting pattern shall be established by the contractor and shall be shown on the appropriate fabrication drawings. Deviation from the established release procedure shall not be permitted except upon written request by the contractor.

Concrete strength shall be determined from concrete test cylinders made in conformance with the requirements of Article 40.06(A) and MT-101 and MT-111 of the State of Montana Materials Manual. The State Inspector shall provide copies of test methods MT-101 and MT-111. These instructions shall be posted at each site of casting concrete test cylinders.

Cylinders cast for determination of prestress transfer strength shall be cast by the contractor in accordance with the above test methods and as modified herein. The release cylinders shall be cast and cured within the curing enclosure, under the exact conditions and method used to cure the prestressed members. Upon completion of the cure cycle the release cylinders shall be tested by the contractor. For determination of prestress transfer strength of each round of multiple beam castings, three cylinders shall be tested. Each cylinder shall have a strength of at least 95 percent of the transfer strength required; however, the average strength of the three cylinders must be equal to or greater than the minimum required transfer strength. The three cylinders required above shall constitute a test for determination of transfer strength. The test shall be completed within a time period not to exceed 30 minutes.

For a one beam casting, prestress transfer strength may be accepted on the basis of the satisfactory test results of one compression specimen.

It shall be the responsibility of the contractor to furnish a sufficient number of release cylinders to satisfy the conditions of these test procedures.

Additional "back-up" test specimens shall be provided at the discretion of the contractor.

In the event that release strengths are not met and all "back-up" specimens have been broken, the casting shall be given at least one additional complete cure cycle. Other testing to determine release strengths, i.e., core samples or non destructive testing shall be accomplished as determined necessary by the Construction Bureau.

Compression specimens shall be broken in accordance with ASTM C-39 with specific attention given to the following: Approximately the last one-half of the load shall be applied at a rate of 1200 to 3000 psi per minute.

The casting and testing of release cylinders shall be witnessed by the plant inspector and under no circumstance shall such casting or testing be performed without prior notification of the inspector.

(J) Post-Tensioning. Tensioning of the prestressing reinforcement shall not be commenced until tests on concrete cylinders, manufactured of the same concrete and cured under the same conditions, indicate that the concrete of the particular member to be pre-stressed has attained the compressive strength specified on the approved fabrication drawings.

After the concrete has attained the required strength the prestressing reinforcement shall be stressed by means of jacks to the desired tension and the stress transferred to the end anchorage.

The tensioning process shall be so conducted that tension being applied and elongation of the pre-stressing elements may be measured at all times.

A record shall be kept of gauge pressures and elongation at all times and submitted to the engineer for his approval.

(K) Bonding Steel. Post-tensioned steel shall be bonded to the concrete except when, in the opinion of the engineer, such bonding is not practicable.

All prestressing reinforcement to be bonded to the concrete shall be free of dirt, loose rust, grease, or other deleterious substances. After completion of the post-tensioning, all conduits shall be first flushed out with water and then blown out with air. If a rubber sheath has been used as the enclosure, it shall be completely removed and the void treated as described above. The conduit or void shall then be entirely filled with the specified grout under a pressure not to exceed 100 psi. This grouting operation shall be continued until a steady flow of the grout is emitted from the pipe opening at the other end of the conduit being grouted. This opening shall then be closed while the grout is under pressure, and finally

the grouting tube connection closed. The final pressure placed on the grout shall be 50 to 100 psi.

(L) Concrete Surface Finish. Prestressed concrete girders shall be fabricated so as to result in well-formed closely matching members that are pleasing in appearance. The degree of workmanship reflected in setting forms and the condition of the forms will be a contributing factor in the amount of concrete finish work required for the acceptable completion of the member.

Prestressed concrete girders shall be finished according to the following requirements:

The exterior surface of exterior members and the entire bottom flange of all girders to its juncture with the beam web shall be given an ordinary finish as set forth in Article 41.01(L)(1) of these specifications.

All other surfaces of the beam shall be considered satisfactory as removed from the forms provided the surfaces are true, even and free from stone pockets, depressions or projections beyond the surface. Holes caused by trapped air at the surface of the concrete will not be considered to be defects except that air holes measuring one-half inch or more in any direction shall be pointed with mortar and struck off even with the adjacent surface. Concrete surfaces that do not exhibit the required smooth, even surface of uniform texture and appearance shall be brought to section using power grinders, carborundum stones, bush-hammers or other approved equipment. Areas requiring surface repair of this magnitude shall then be given an ordinary finish. The appearance of any repair area shall blend closely with that of the existing surface adjacent to the repair. Areas that cannot be finished to blend with the adjacent area will necessitate application of the ordinary finish to the entire adjoining surface of the member.

Rock pockets shall not be repaired without prior inspection and evaluation by the plant inspector. Rock pockets shall be chipped back to sound concrete, cleaned and inspected prior to patching. Rock pockets of such extent or character as to affect the strength of the member shall be referred to the Construction Bureau for evaluation. Any member in which the prestressing strand is exposed for a distance of eight inches or more on any one strand or any exposure of more than one strand shall be referred to the Construction Bureau prior to repair.

Beam ends, unless embedded in concrete shall be given an ordinary finish. The contractor may use approved proprietary epoxy or quick-setting grout products for this purpose provided the colors blend. Prior to finishing, the strands shall be cut back a minimum of one-half inch and the

depression filled with an approved epoxy. When beam ends are embedded in concrete, the ends may be left rough and strands shall be cut back so as not to project more than one inch beyond the surface of the concrete. Strands in the area of the paving notch shall be cut flush with the surface of the concrete. The top surface of prestressed girders shall be screeded off and rough floated to establish the proper depth of the member, to bring grout to the surface and cover all aggregate. This finish shall be acceptable as the final beam top treatment at the site of fabrication. Prior to beginning the cure cycle all projecting reinforcing stirrups shall be cleaned of mortar deposits and other foreign materials. Concrete finish work shall be accomplished insofar as is practicable, while the concrete is warm and moist.

Concrete finishing shall not commence until after detensioning operations have been completed.

(M) Workmanship and Tolerances. All tolerances shall be applied with respect to the theoretical positions and dimensions shown on the plans and approved fabrication drawings.

The tolerances listed in this Article represent the total allowable tolerance that will be accepted in the finished product. Tolerances allowed in other manufacturing sequences shall not be accumulated to supersede any individual tolerance. Members having dimensions outside the tolerance limits shall be subject to rejection.

Length of beam end to end measured at centerline of beam, top or bottom flange.			$\pm 3/4''$
Centerline to centerline of end bearing plates.			1/8" per 10' but not greater than 1/2"
Depth of flanges, fillets and web.			$\pm 1/4''$
Depth overall.			+ 1/2" to - 1/4"
Width of flanges, fillets and web.			+ 3/8" to - 1/4"
Beam ends - deviation from square or designated skew.	horizontal	$\pm 1/4''$	
	vertical	1/8" per foot of beam height or 1/2" whichever is less.	
Side insert, center to center and center to beam end.			$\pm 1/2''$
Horizontal alignment (deviation from a straight line parallel to centerline of the member measured on the bed, immediately after release of prestress).			1/8" per 10' of beam length but not greater than 1"

Camber differential between adjacent beams measured at release of prestress. (To be applied only to identical members cast in same line.)	1/8" per 10' of span, to a maximum of 1"
Stirrup bars (specified projection above beam top).	$\pm 1/2"$
Tendon position.	$\pm 1/4"$ in center of gravity of strand group & individual tendons.
Position of deflection points for deflected strands.	$\pm 6"$
Position of handling devices along centerline of beam.	$\pm 6"$
Centerline of bearing plates to end of beam.	$\pm 1/4"$
Bearing plates (deviation from a plane perpendicular to the vertical axis of the beam).	$\pm 1/16"$
Stirrup bars (longitudinal spacing).	$\pm 1"$
Position of post-tensioning ducts.	$\pm 1/4"$

(N) Storage and Transportation. Extreme care shall be exercised in handling and moving precast prestressed concrete members. Precast girders and slabs shall be transported in an upright position and the points of support and directions of the reactions with respect to the member shall be approximately the same during transportation and storage as when the member is in its final planned position. If the contractor deems it expedient to transport or store precast units in other than this position, it shall be done at his own risk after notifying the inspector, in writing, of his intention to do so.

Care shall be taken during storage, hoisting, and handling of the precast units to prevent cracking or damage.

Lifting of beams shall be done only by use of the lifting eyes. During lifting of the beams, spreaders shall be used between slings to eliminate the horizontal component of the lifting force applied to the beam, except that when the angle between the sling and the top of the beam exceeds 45 degrees, a spreader will not be required.

Prestressed members shall not be moved from the casting yard until the 28-day strength of the concrete has been attained and the plant inspector has been notified of the intent to transport the member.

Units damaged by improper storing or handling shall be replaced by the contractor at his expense.

(O) **Placing.** Precast, prestressed structural members shall be placed in the structure in conformity with the plans and special provisions governing the particular type of structure to be built.

Precast prestressed concrete piling shall be placed in agreement with the requirements for precast concrete piling in Section 46.

42.06 METHOD OF MEASUREMENT. The quantity to be paid for shall be the actual number of precast prestressed concrete structural members, except piling, of the several types and sizes, installed in place, completed and accepted. Each member shall include the concrete, reinforcement and prestressing steel, enclosures for prestressing steel, bearing plates and rockers, anchor bolts and nuts and other such material contained within or attached to the unit. Piling will be measured as provided in Section 46.

42.07. BASIS OF PAYMENT. The precast, prestressed members, except piling shall be paid for at the contract unit price per member, determined as provided above, complete in place, which price and payment shall constitute full compensation for furnishing all materials, precasting, prestressing, transportation, and erecting complete in place, and for all labor, equipment, tools and incidentals necessary to complete the item.

Precast prestressed concrete piling will be measured and paid for as provided in Section 46, "Piling".

SECTION 43

STEEL STRUCTURES

43.01 DESCRIPTION. This work shall consist of steel structures and the steel structure portions of composite structures, constructed in conformity with the lines, grades, and dimensions shown on the plans.

The work shall include the furnishings, fabricating, erecting and painting of structural metals called for in the special provisions or shown on the plans. Structural metals shall include structural, rivet, welding, special, and alloy steels, metallic electrodes, steel forgings and castings, and iron castings. This work shall include incidental metal construction not otherwise provided for.

43.02 FIELD OFFICE. The Department will furnish all field offices and laboratories unless otherwise specified. Electricity and water shall be furnished according to the provisions of Article 06.05.

43.03 FABRICATION DRAWINGS. Prior to fabricating any structural steel, the contractor shall submit to the engineer for approval, fabrication drawings which show complete details, dimensions, size of material and other information and data necessary for the complete fabrication and erection of the metal work. Approval of fabrication plans shall be secured before fabrication of steel work is commenced. The contractor shall furnish prints of the fabrication drawings, in quadruplicate, for approval, and after approval he shall furnish three or more prints, as required, of the approved drawings. All fabrication drawings shall be 22 inches x 36 inches with a 1 1/2 inch margin on the left side and a one-half inch margin on the other three sides. Upon completion of the work the original tracings, if required, shall be supplied to the engineer. No deviation from the approved plans will be permitted without a written order from the engineer. Changes on approved drawings shall be subject to the approval of the engineer, and he shall be supplied with a record of such changes. Substitutions of sections different from those shown on the drawings shall be made only when approved in writing.

43.04 MATERIALS. Except when otherwise specified, all materials used in this work shall be new and shall conform to the requirements of section M-290.

Unless otherwise specified on the plans or in the special provisions, structural steel conforming to ASTM A-36 shall be used. All other materials

used shall be those prescribed for the various other items which constitute the structure.

43.05 MILL AND SHOP INSPECTION.

(A) Notice of Beginning of Work. The contractor shall give the engineer ample notice of the beginning of work at the mill or in the shop, so that inspection may be provided. The term "mill" means any rolling mill or foundry where material for the work is to be manufactured. No material shall be manufactured or work done in the shop before the engineer has been so notified.

(B) Facilities for Inspection. The contractor shall furnish facilities for the inspection of material and workmanship in the mill and shop, and the inspectors shall be allowed free access to the necessary parts of the work.

(C) Inspector's Authority. The inspector shall have the authority to reject material or work which does not meet the specifications. In case of dispute, the contractor may appeal to the engineer, whose decision shall be final.

(D) Mill Orders and Shipping Statements. The contractor shall furnish the engineer with as many copies of mill orders and shipping statements as he may direct. The weights of the individual members shall be shown on the statements.

(E) Facilities for Testing. The contractor shall furnish test specimens, as specified herein, labor, testing machines and tools necessary to make the specimens and full-size tests at no cost to the Department.

(F) Welding. The contractor shall comply with all demands of the inspector relative to inspection of fabrication of steel by welding.

(G) Rejections. The acceptance of material or finished members by the inspector shall not be a bar to their subsequent rejection, if found defective. Rejected material and workmanship shall be replaced promptly or made good by the contractor.

43.06 FABRICATION. Structural steel shall be fabricated in accordance with the following requirements:

(A) Storage of Materials. Structural steel shall be stored in conformity with Article 43.10 (B).

Alloy and high strength steels shall be plainly marked at frequent intervals for identification. These marks shall be of such nature and spacing that they will be readily visible on all pieces during fabrication.

Material that must meet a Charpy requirement, as shown on the plans, shall be plainly marked for identification. These marks shall be of such nature and spacing that they will be readily visible on all pieces during fabrication.

(B) Workmanship and Finish. The workmanship and finish shall be equal to the best practice in modern bridge shops.

All edges of material, subject to a design load, shall have the corners rounded to a radius of one-sixteenth inch. Shearing, flame cutting and chipping shall be neatly and accurately done and all portions of the work exposed to view shall be neatly finished.

Rolled material before being laid out or worked must be straight. If straightening is necessary, it shall be done by methods that will not injure the metal. Sharp kinks and bends shall be cause for rejection of the material.

(C) Finishing and Shaping. Finished members shall be true to line and free from twists, bends and open joints.

(1) Edge Planing. Sheared edges of plates more than five-eighths inch in thickness and carrying calculated stress shall be planed to a depth of one-fourth inch. Re-entrant cuts shall be filleted before cutting.

(2) Facing of Bearing Surfaces. The surface finish of bearing and base plates and other bearing surfaces that are to come in contact with each other or with concrete shall meet the surface roughness requirements as defined in A.S.A.B. 46.1, Surface Roughness, Waviness and Lay, Part I:

Steel slabs.....	ANSI 2,000
Heavy plates in contact in shoes to be welded.....	ANSI 1,000
Milled ends of compression members, stiffeners, and fillers.....	ANSI 500
Bridge rollers and rockers.....	ANSI 250
Pins and pin holes.....	ANSI 125
Sliding bearings.....	ANSI 125

(3) Abutting Joints. Abutting joints in compression members, girder flanges, and tension members, where so specified on the drawings shall be faced and brought to an even bearing. Where joints are not faced, the openings shall not exceed one-fourth inch.

(4) End Connection Angles. Floor beams, stringers and girders having end connection angles shall be built to exact length back to back of

connection angles. If end connections are faced, the finished thickness of the angles shall not be less than that shown on the detail drawings.

(5) **Web Plates.** At web splices, the clearance between the ends of the web plates shall not exceed three-eighths inch. The clearance at the top and bottom ends of the web splice plates shall not exceed one-fourth inch.

(6) **Bent Plates.** Cold-bent load-carrying rolled-steel plates shall conform to the following:

(a) They shall be taken from the stock plates so the bend line will be at right angles to the direction of rolling.

(b) The radius of bends, measured to the concave face of the metal, shall not be less than shown in the following table, in which "T" is the thickness of the plate:

Angle through which plate is bent	Minimum radius
61 degrees to 90 degrees.....	1.0 T
91 degrees to 120 degrees.....	1.5 T
121 degrees to 150 degrees.....	2.0 T

If a shorter radius is essential, the plates shall be bent hot. Hot-bent plates shall conform to requirement (a) above.

(c) Before bending, the corners of the plate shall be rounded to a radius of one-sixteenth inch throughout that portion of the plate at which the bending is to occur.

(7) **Fit of Stiffeners.** End stiffener plates or angles of girders and stiffeners intended as supports for concentrated loads shall be milled or ground to secure an even bearing against the flange. Intermediate stiffeners shall fit as set forth on the plans. Fillers under stiffeners shall fit within one-fourth inch at each end. Welding will be permitted in lieu of milling or grinding if noted on the plans or specified in the special provisions. Welding transversely across the tension flanges of beams or girders will not be permitted except as otherwise approved.

Horizontal stiffeners shall be of such length as to leave a gap no greater than one-half inch between the vertical stiffeners and the end of the horizontal stiffeners.

(8) **Flame Cutting.** Steel or wrought-iron may be flame cut, provided a smooth surface is secured by the use of a mechanical guide. Flame cutting by hand shall be done only where approved and the surface shall be made smooth by planing, chipping or grinding. The cutting flame

shall be so adjusted and manipulated as to avoid cutting beyond the prescribed lines. Re-entrant cuts shall be filleted to a radius of not less than one-half inch.

In the case of silicon steel, flame cut edges shall be removed to a depth of at least one-fourth inch by milling, chipping or grinding, except that machine flame-cut edges may be used without such removal if the edges are softened after cutting: (a) by heating the cut edge uniformly and progressively to a red heat, visible in ordinary shop light (1,150 degrees to 1,250 degrees F.) to a depth of at least one-sixteenth inch; or (b) by means of a post-heating torch attached to and following the cutting torch; the tips, gas pressure, speed of travel and the distance of post-heating torch from kerf regulated to the thickness of the steel.

(D) Pins and Rollers.

(1) **General.** Pins and rollers shall conform to Article M-290.04.

(2) **Boring Pin Holes.** Pin holes shall be bored true to the specified diameter, smooth and straight, at right angles with the axis of the member and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut. The distance outside to outside of holes in tension members and inside to inside of holes in compression members shall not vary from that specified more than one-thirty second inch. Boring of holes in built-up members shall be done after the welding and riveting is completed.

(3) **Pin Clearances.** The diameter of the pin hole shall not exceed that of the pin by more than one-fiftieth inch for pins five inches or less in diameter, or one-thirty second inch for larger pins.

(4) **Surface Finish.** The surface finish of bridge rollers and rockers and pins and pin holes shall be specified in Article 43.06 (C) (2).

(5) **Pilot and Driving Nuts.** Two pilot nuts and two driving nuts for each size of pin shall be furnished, unless otherwise specified. Pilot and driving nuts will not be required when shoes are assembled at the fabrication plant.

(6) **Threads.** Thread for pins shall conform to the American National Course Series. Class 2, free fit, except that the pin ends having a diameter of 1-3/8 inches or more shall be threaded six threads to the inch.

(E) Bolt and Rivet Holes.

(1) **General.** All holes for bolts and rivets shall be either punched or drilled.

Material, forming parts of a member composed of not more than five thicknesses of metal, may be punched one-sixteenth inch larger than the nominal diameter of the rivet or bolt whenever the thickness of the metal is not greater than three-quarter inch for carbon steel or five-eighths inch for alloy steel.

When there are more than five thicknesses or when the main material is thicker than three-quarters inch in carbon steel, or five-eighths inch in alloy steel, all holes shall be subpunched or sub drilled three-sixteenth inch smaller and, after assembling, reamed one-sixteenth inch larger, or drilled from the solid to one-sixteenth inch larger, than the nominal diameter of the rivets or bolts.

(2) Punched Holes. Holes punched full-size shall be one-sixteenth inch larger than the nominal diameter of the rivet or bolt. The diameter of the die shall not exceed the diameter of the punch by more than one-sixteenth inch. If holes must be enlarged to admit the rivets, they shall be reamed. Holes shall be clean cut, without torn or ragged edges. Poor matching of holes will be cause for rejection.

(3) Accuracy of Punched and Subdrilled Holes. All holes punched full size, subpunched, or subdrilled shall be so accurately punched that after assembling (before any reaming is done) a cylindrical pin one-eighth inch smaller in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member, without drifting, in at least 75 percent of the contiguous holes in the same plane. If the requirement is not fulfilled, the badly punched pieces will be rejected. If any hole will not pass a pin three-sixteenths inch smaller in diameter than the nominal size of the punched hole, this will be cause for rejection.

(4) Reamed or Drilled Holes. Reamed holes shall be cylindrical, perpendicular to the member and not more than one-sixteenth inch larger than the nominal diameter of the rivets or bolts. Where practicable, reamers shall be directed by mechanical means. Drilled holes shall be one-sixteenth inch larger than the nominal diameter of the rivets or bolts. Burns on the outside surfaces shall be removed. Poor matching of holes will be cause for rejection. Reaming and drilling shall be done with twist drills. If required, assembled parts shall be taken apart for removal of burrs caused by drilling. Connecting parts requiring reamed or drilled holes shall be assembled and securely held while being reamed or drilled and shall be match-marked before assembling.

(5) Accuracy of Reamed and Drilled Holes. When holes are

reamed or drilled, 85 percent of the holes in any contiguous group shall, after reaming or drilling, show no offset greater than one-thirty second inch between adjacent thickness of metal.

(F) Riveted Connections.

(1) General. The size of rivets called for on the plans shall be the size before heating. Rivet heads shall be of standard shape, unless otherwise specified, and of uniform size for the same diameter of rivet. They shall be full, neatly made, concentric with the rivet holes, and in full contact with the surface of the member.

(2) Shop Riveting. Rivets shall be heated uniformly to a "light cherry red color" and shall be driven while hot. A rivet whose point is heated more than the remainder shall not be driven. When a rivet is ready for driving, it shall be free from slag, scale and other adhering matter. A rivet which, in the opinion of the engineer, is scaled excessively will be rejected. Rivets that are loose, burned, badly formed, or otherwise defective shall be removed and replaced with satisfactory rivets. A rivet whose head is defective in size or whose head is driven off center will be considered defective and shall be removed. Stich rivets that are loosened by driving of adjacent rivets shall be removed and replaced with satisfactory rivets. Caulking, recupping or double gunning rivet heads will not be permitted.

Shop rivets shall be driven by direct-acting rivet machines when practicable. Approved beveled rivet sets shall be used for forming rivet heads on sloping surfaces. When the use of a direct acting rivet machine is not practicable, pneumatic hammers of approved size shall be used. Pneumatic bucking tools will be required when, in the opinion of the engineer, the size and length of the rivets warrant their use. Rivets may be driven cold provided their diameter is not over three-eighths inch.

(3) Field Riveting. Pneumatic hammers shall be used for field riveting, except when the use of hand tools is permitted. Rivets larger than seven-eighths inch in diameter shall not be driven by hand. Cup-faced dollies, fitting the head closely to insure good bearing, shall be used. Connections shall be accurately and securely fitted up before the rivets are driven. Drifting shall be only such as to draw the parts into position and not sufficient to enlarge the holes or distort the metal. Unfair holes shall be reamed or drilled. Rivets shall be heated uniformly to a light cherry-red color and shall be driven while hot. They shall not be overheated or burned. Rivet heads shall be full and symmetrical, concentric with the shank, and shall have full bearing all around. They shall not be smaller

than the heads of the shop rivets. Rivets shall be tight and shall grip the connected parts securely together. Caulking or recupping will not be permitted. In removing rivets, the surrounding metal shall not be injured; if necessary, they shall be drilled out. Field driven rivets shall be inspected and accepted before being painted.

(4) Spacing and Edge Distance of Rivets. The minimum distance from the center of a rivet to the center of the nearest rivet shall be three times the diameter of the rivet, but not less than the following:

For 1 inch rivets, 3 1/2 inches

For 7/8 inch rivets, 3 inches

For 3/4 inch rivets, 2 1/2 inches

For 5/8 inch rivets, 2 1/4 inches

The minimum distance from the center of a rivet to the nearest sheared edge and to the edges of beams and channels shall be:

For 1 inch rivets, 1 3/4 inches

For 7/8 inch rivets, 1 1/2 inches

For 3/4 inch rivets, 1 1/4 inches

For 5/8 inch rivets, 1 1/8 inches

The minimum distance from the center of a rivet to the nearest rolled or planed edge shall be:

For 1 inch rivets, 1 1/2 inches

For 7/8 inch rivets, 1 1/4 inches

For 3/4 inch rivets, 1 1/8 inches

For 5/8 inch rivets, 1 inch

The maximum distance from the center of a rivet to the nearest edge shall be eight times the thickness of the thinnest outside plate, but shall not exceed five inches.

(G) Bolts and Bolted Connections.

(1) General. Bolted connections shall be used only as shown on the plans. Where bolted connections are permitted, the bolts furnished shall be unfinished bolts (ordinarily rough or machine bolts) unless otherwise specified. Turned bolts shall be provided where shown on the plans, or required by the special provisions. Special ribbed drive fit bolts may be substituted for turned bolts upon written approval. Bolted connections fabricated with high tensile strength bolts shall conform to paragraph (4) of this article.

Bolts shall be driven accurately into the holes without damaging the thread. A snap shall be used to prevent damaging the heads.

The heads and nuts shall be drawn tight against the work with a suitable

wrench. Bolt heads shall be tapped with a hammer while nut is being tightened. Where bolts are to be used in beveled surfaces, beveled washers shall be provided to give full bearing to the head or nut. All bolts shall have cut threads neatly and accurately finished. The nuts of unfinished, turned bolts and ribbed bolts shall be effectually locked after they have been finally tightened.

(2) Unfinished Bolts. Unfinished bolts shall be standard bolts with hexagonal heads and nuts. The diameter of the bolt holes shall be one-sixteenth inch greater than the diameter of the bolts used. Bolts transmitting shear shall be threaded to such a length that not more than one thread will be within the grip of the metal. The bolts shall be of such length that they will extend entirely through their nuts, but not more than one-quarter inch beyond them.

(3) Turned Bolts. Holes for turned bolts shall be carefully reamed and the bolts turned to a driving fit with the threads entirely outside of the holes and a washer shall be used. The heads and nuts shall be hexagonal. Turned bolts shall be finished by a finishing cut.

(4) Bolted Connections, High-Tensile-Strength Bolts.

(a) Unless otherwise specified, high tensile bolts, nuts and washers shall meet the requirements of Article M-290.06.

(b) Bolt lengths. Bolt lengths shall be determined by adding the grip-length values given in table 43-1 to the total thickness of connected material. The values in table 43-1 compensate for thickness of nut, one flat washer, and bolt point. The total length shall be adjusted to the next one-fourth inch increment up to a five inch length and to the next one-half inch increment for lengths over five inches.

Table 43-1 — Bolt Length Determination

Bolt diameter side	Added grip length*
1/2	7/8
5/8	1
3/4	1 1/8
7/8	1 3/8
1	1 1/2
1 1/8	1 5/8
1 1/4	1 3/4

*To be added to total thickness
of connected material

If other than standard thickness of circular washer is to be used, the necessary bolt length shall be adjusted accordingly. Where beveled washers are to be used, bolt lengths shall be adjusted accordingly.

(c) Bolted Parts. Surfaces of bolted parts in contact with the bolt head and nut shall not have a slope of more than 1:20 with respect to a plane normal to the bolt axis. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or other interposed compressible material. Holes may be punched, sub-punched and reamed or drilled, as required by the applicable specifications and shall be of a nominal diameter not more than one-sixteenth inch in excess of the nominal bolt diameter.

When assembled, all joint surfaces, including those adjacent to the washers, shall be free of scale except tight mill scale. They shall be free of dirt, loose scale, burrs, and other defects that would prevent solid seating of the parts.

Contact surfaces shall be free of oil, paint, lacquer, or galvanizing.

(d) Installation. Bolts shall be installed with a hardened washer under the nut or bolt head, whichever is the element turned in tightening. A hardened washer shall also be used under the head of regular semi-finished hexagon bolts and under finished hexagon nuts, even when these are not the elements turned in tightening. The washer may be omitted under the head of heavy semi-finished hexagon bolts and interference-body bolts, and under heavy semi-finished hexagon nuts, when these are not the elements turned. A flat washer may be used when the abutment surface adjacent to the bolt head or nut does not have a slope of more than 1:20 with respect to a plane normal to the bolt axis. Where an outer face of the bolted parts has a slope of more than 1:20 with respect to a plane normal to the bolt axis, a smooth beveled washer shall be used to compensate for lack of parallelism.

Each fastener shall be tightened to provide, when all fasteners in the joint are tight, at least the minimum tension shown in Table 43-2 for the size and grade of fastener used.

Threaded bolts shall be tightened by methods described in subparagraphs one and two of this section. If required because of bolt entering and wrench operation clearances, tightening by either procedure described in subparagraphs (1) or (2) may be done by turning the bolt while the nut is prevented from rotating.

Table 43-2 — Fastener Tension

Bolt Size, in Inches	*Minimum Fastener Tension
	A325 Bolts (Pounds)
1/2	12,050
5/8	19,200
3/4	28,400
7/8	39,250
1	51,500
1 1/8	56,450
1 1/4	71,700
1 3/8	85,450
1 1/2	104,000
*Equal to 70 percent of specified minimum tensile strengths of bolts.	

Impact wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately ten seconds.

(1) Turn-of-Nut Tightening. When the turn-of-nut method is used to provide the bolt tension specified in Table 43-2, there shall first be enough bolts brought to a “snug tight” condition to insure that the parts of the joint are brought into good contact with each other. Snug tight is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Following this initial operation, bolts shall be placed in any remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be tightened additionally by the applicable amount of nut rotation specified in Table 43-3, with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation there shall be no rotation of the part not turned by the wrench.

In order to determine relative rotation, the contractor shall match mark the bolt and nut with a crayon or other means after they have been brought to the “snug tight” condition.

Table 43-3 — Nut Rotation from Snug Tight Condition

Disposition of Outer Faces of Bolted Parts			
Bolt Length (as measured from underside of head to extreme end of point)			
	Both faces nor- mal to bolt axis	One face nor- mal to bolt axis and other face sloped not more than 1:20 (bevel washer not used)	Both faces slop- ed not more than 1:20 from normal to bolt axis (bevel washers not used)
Up to and including 4 diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 diameters but not exceeding 8 diameters	1/2 turn	2/3 turn	5/6 turn
Over 8 diameters but not exceeding 12 diameters	2/3 turn	5/6 turn	1 turn

(a) Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. For bolts installed by one-half turn and less the tolerance shall be plus or minus 30° (one-twelfth turn), for bolts installed by two-thirds turn and more the tolerance shall be plus or minus 45° (one-eighth turn).

(b) The required rotation for bolts exceeding twelve diameters shall be determined by testing representative bolts in a tension device.

(2) **Calibrated Wrench Tightening.** When calibrated wrenches are used, they shall be set to provide a tension at least five percent in excess of the minimum bolt tension specified. The wrenches shall be calibrated at least once each working day for each bolt diameter being installed. Wrenches shall be recalibrated when significant changes are made in the equipment or when a significant difference is noted in the surface condition of the bolts, nuts or washers. Calibration shall be accomplished by tightening, in a device capable of indicating actual bolt tension, three typical bolts of each diameter from the bolts being installed.

When adjusting the wrenches to provide the required tension, it shall be verified during actual installation in the assembled steelwork that the calibration selected does not produce a nut or bolt head rotation from snug tight greater than that permitted in Table 43-3. If manual torque wrenches are used, nuts shall be in tightening motion when torque is measured.

When using calibrated wrenches to install several bolts in a single joint, the wrench shall be returned to "touch up" bolts previously tightened, which may have been loosened by the tightening of subsequent bolts, until all are tightened to the prescribed amount.

Power wrenches shall be adjusted to stall or cut-out at the required tension.

(e) Inspection

(a) The engineer shall determine that the requirements of this specification are met in the work. When the calibrated wrench method of tightening is used, the Inspector shall have full opportunity to witness the calibration tests prescribed in paragraph 43.06 (G)(4)(d)(2).

(b) The engineer shall observe the installation of bolts to determine that the selected procedure is properly used and shall determine that all bolts are tightened.

The engineer may use an inspecting wrench which may be either a torque wrench or a power wrench that can be adjusted in accordance with the requirements of paragraph 43.06 (G) (4) (d) (2).

Three bolts of the same grade, size* and condition as those under inspection shall be placed individually in a calibration device capable of indicating bolt tension. The surface under the part to be turned in tightening each bolt shall be like that under the corresponding part in the structure; i.e., there shall be a washer under the part turned if washers are so used in the structure or, if no washer is used, the material abutting the part turned shall be of the same specification as that in the structure.

When the inspecting wrench is a torque wrench, each of the three bolts shall be tightened in the calibration device by any convenient means to an initial condition equal to approximately 15 percent of the required fastener tension and then to the minimum tension specified for its size. Tightening beyond the initial condition must not produce greater nut rotation than that permitted in Table 43-3. The inspecting wrench then shall be applied to the tightened bolt and the torque necessary to turn the

*Length may be any length representative of bolts used in the structure.

nut or head five degrees (approximately one inch at twelve inch radius) in the tightening direction shall be determined. The average torque measured in the tests of three bolts shall be taken as the job inspecting torque to be used in the manner specified.

When the inspecting wrench is a power wrench it shall be adjusted so that it will tighten each to a tension at least five percent but not more than ten percent greater than the minimum tension specified for its size in Table 43-2. However, this power wrench setting must not produce greater nut rotation from the snug condition than that permitted in Table 43-3. This setting of wrench shall be taken as the job inspecting torque to be used in the manner specified in the preceding paragraph.

Bolts represented by the sample prescribed, which have been tightened in the structure shall be inspected by applying, in the tightening direction, the inspecting wrench and its job inspecting torque to at least ten percent of the bolts, but not less than two bolts, selected at random in each connection. If any nut or bolt head is turned by the application of the job inspecting torque, the contractor shall check all bolts in the connection and re-submit it for the specified inspection.

(H) Welding Requirements. All welding shall comply with the requirements of current editions of the AASHTO specifications, the American Welding Society specifications as well as the plans and special provisions.

(I) Welded Stud Shear Connectors. The type, size or diameter and length of stud shear connectors shall be as required by the plans, specifications or special provisions as approved by the engineer.

The fabrication material and welding shall conform to the requirements of paragraph (H) above.

43.07 ASSEMBLING STEEL. Steel parts shall be assembled in the shop or in the field in accordance with the following:

(A) Shop Work Surfaces of metal in contact shall be cleaned before assembling.

At the time of assembling and riveting, bolting or welding, steel surfaces in contact for shop or field connection shall be thoroughly cleaned of rust, mill scale, dirt, grease, or other material foreign to steel. No paint shall be applied to contact surfaces prior to riveting, bolting or welding.

Riveted or bolted trusses, continuous plate girder and I-beam spans, skew portals, skew connections, rigid frames, bents, and towers, shall be completely assembled in the shop and accurately adjusted to line and

camber and holes for field connections drilled and reamed while assembled. Holes for other field connections, except those in lateral, longitudinal and sway bracing, shall be drilled or reamed in the shop with the connecting parts assembled, drilled, or reamed to a metal template with hardened bushings, without assembling.

Long span truss work shall be assembled in lengths of not less than 3 abutting panels, the members adjusted for line and camber and holes for field connections drilled or reamed while assembled.

Field riveted or bolted joints for girders shall be assembled with the abutting members adjusted for line and camber and holes for field connections drilled or reamed while assembled.

Field butt joints for welded girders shall be assembled with abutting members adjusted for line and camber and prepared to fit for welding.

Expansion devices for bridges shall be assembled in the shop sufficiently to determine that a proper fit between the various component parts of each joint has been achieved.

(B) Field Work. The parts shall be accurately assembled as shown on the plans and all match-marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken, or otherwise damaged. Hammering which could injure or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Unless erected by the cantilever method, truss spans shall be erected on blocking so placed as to give the trusses proper camber. The blocking shall be left in place until the tension chord splices are fully riveted or bolted and all other truss connections pinned and bolted. Rivets or bolts in splices of butt joints of compression members and rivets or bolts in railings shall not be driven or torqued until the span has been swung. Splices and field connections shall have one-half of the holes filled with bolts and cylindrical erection pins (half bolts and half pins) before riveting or bolting. Splices and connections carrying traffic during erection shall have three-fourths of the holes so filled.

Fitting up bolts shall be of the same nominal diameter as the rivets, and cylindrical erection pins shall be 1/32 inch larger.

(C) Drifting of Holes. The drifting done during assembling shall be only such as to bring the parts into position, and not sufficient to enlarge the holes or distort the metal. If holes must be enlarged to admit the rivets, they shall be reamed.

(D) Match-marking. Connecting parts assembled in the shop for

reaming holes in field connections shall be match-marked, and a diagram showing such marks shall be furnished to the engineer.

43.08 MARKING AND SHIPPING. Each member shall be painted or marked with an erection mark for identification and an erection diagram shall be furnished with erection marks shown thereon.

The contractor shall furnish as many copies of material orders, shipping statements and erection diagrams as the engineer may direct. The weights of the individual members shall be shown on the statements.

Members weighing more than three tons shall have the weights marked thereon. Structural members shall be loaded on trucks or cars in such a manner that they may be transported and unloaded at their destination without being excessively stressed, deformed or otherwise damaged.

Bolts and rivets of one length and diameter and loose nuts or washers of each size shall be packed separately. Pins, small parts and packages of bolts, rivets, washers and nuts shall be shipped in boxes, crates, kegs or barrels, but the gross weight of a package shall not exceed 300 pounds. A list and description of the contained material shall be plainly marked on the outside of each shipping container.

The loading, transportation, unloading, and sorting of structural material shall be conducted so that the metal will be kept clean and free from injury.

43.09 PAINTING. All iron and steel surfaces shall be cleaned and painted in accordance with the provisions in section 91.

43.10 CONSTRUCTION METHODS.

(A) General. The contractor shall erect the metal work, remove the temporary construction, and do all the work required to complete the structure or structures as covered by the contract, all in accordance with the plans and specifications.

(B) Handling and Storing Materials. Materials to be stored shall be placed on skids above the ground. It shall be kept clean and properly drained. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent injury from deflection. If the contract is for erection only, the contractor shall check the material turned over to him against the shipping lists and report promptly in writing any shortage or injury discovered. He shall be responsible for the loss of material while in his care, or for damage caused to it after being received by him.

(C) **Falsework.** The falsework shall be properly designed and substantially constructed and maintained for the loads which will come upon it. The contractor, if required, shall prepare and submit to the engineer for approval, plans for falsework or for changes in an existing structure necessary for maintaining traffic. Approval of the contractor's plans shall not be considered as relieving the contractor of any responsibility.

(D) **Methods and Equipment.** Before starting the work of erection, the contractor shall inform the engineer fully as to the method of erection he proposes to follow, and the quantity and character of equipment he proposes to use, which will be subject to approval. The approval of the engineer will not be considered as relieving the contractor of the responsibility for the safety of his method or equipment or from carrying out the work in full accordance with the plans and specifications. No work shall be done until such approval has been obtained.

(E) **Bearing and Anchorage.** Masonry bearing plates shall not be placed upon bearing areas which are improperly finished, deformed or irregular. Bearing plates shall be set level in exact position and shall have a full and even bearing upon the masonry.

Unless otherwise directed, masonry bearing plates for bridges shall be placed on canvas and red lead applied as follows:

Thoroughly swab the bridge-seat bearing area with a shop coat of red lead paint and place upon it three layers of 12 to 14 ounce duck, each layer being thoroughly swabbed on its top surface with shop coat red lead paint. Place the superstructure shoes or pedestals in position while the paint is plastic.

In setting shoes or bearing plates for steel truss spans, proper allowances shall be made for bottom chord elongation due to dead load.

Bridge rocker shoes shall be set vertical under full dead load of 60 degrees F. If rockers are not in correct position with final dead load on spans, spans shall be jacked and adjustments made.

When elastomeric bearing pads are used the concrete surfaces on which the pads are to be placed shall be constructed slightly high. While the concrete is still plastic the bearing area shall be finished with a wood float to a level plane which shall not show a variation of more than one-sixteenth inch from a straightedge placed in any direction across the area. The bearing area shall be finished so as to extend at least one inch beyond the limits of the masonry pad. The finished elevation of the concrete bearing surface shall not vary more than one-eighth inch from the beam seat elevation shown on the plans.

(F) Placing Anchor Bolts. Anchor bolts shall be placed as provided in article 41.04 (N).

(G) Straightening Bent Material. The straightening of plates and angles or other shapes shall be done by methods not likely to produce fracture or other injury. The metal shall not be heated unless permitted by the engineer, in which case the heating shall not be to a higher temperature than 1150°F. After heating, the metal shall be cooled as slowly as possible. Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fracture.

(H) Pin Connections. Pilot and driving nuts shall be used in driving pins. They shall be furnished with the steel work and shall be returned to the Department on completion of the work. Pins shall be so driven that the members will take full bearing on them. Pin nuts shall be screwed up tight and the threads burred at the face of the nut with a pointed tool.

(I) Misfits. Corrections of minor misfits and a reasonable quantity of reaming and cutting of excess stock from rivets will be considered a legitimate part of the erection. Any error in shop work which prevents the proper assembling and fitting of parts by the moderate use of drift pins or a moderate quantity of reaming and slight chipping or cutting, shall be reported immediately to the inspector, and his approval of the method of correction obtained. The correction shall be made in the presence of the inspector, who will check the work and material. The contractor shall be responsible for all misfits, errors and injuries and shall make the necessary corrections and replacements.

(J) Cleanup. Upon completion, and before final acceptance, the contractor shall remove all falsework, excavated or useless materials, rubbish and temporary buildings, replace or renew any fences damaged, and restore in acceptable manner all property, both public and private, which may have been damaged during the prosecution of his work. He shall leave the bridge site and adjacent highway in a neat and presentable condition satisfactory to the engineer.

All falsework piling shall be pulled or cut off one foot below finished ground line where conditions will permit. If conditions are not favorable for pulling or cutting of the piles as stated above, the piles shall be either broken or shot off at the stream bed, unless otherwise provided by the engineer. All excavated material or falsework placed in the stream channel during construction shall be removed by the contractor before final acceptance.

(K) **Inspection.** The work shall be subject, at all times, to inspection by the engineer.

43.11 REJECTIONS. The acceptance of material or finished members by the inspector shall not prevent their subsequent rejection, if found defective. Rejected material and workmanship shall be replaced promptly or made good by the contractor.

43.12 METHOD OF MEASUREMENT.

(A) **Unit Basis.** The poundage to be paid for shall be the number of pounds of structural steel of the type or types specified in the fabricated structure including field rivets.

The weight of erection bolts, field paint, boxes, crates and other containers used for packing and materials used for supporting members during transportation shall not be included.

The weights paid for shall be calculated on the basis of the following assumptions:

(1) Unit Weights, pounds per cubic foot	
Iron, Malleable.....	470.0
Iron, Wrought.....	487.0
Steel rolled, cast, copper bearing, silicon, nickel and stainless.....	490.0

(2) The weights of rolled shapes and of plates up to and including 36 inches in width shall be computed on the basis of their nominal weights and dimensions as shown on the approved shop drawings. To the nominal weights of plates more than 36 inches in width, there shall be added one-half of the allowed percentage of overrun in weight as tabulated in ASTM A-6. The weight will be computed on the basis of rectangular dimensions for all plates and overall lengths for all structural shapes and with no deductions for copes, clips, sheared edges, punchings, borings, milling or planing, provided however, that when parts can be economically cut in multiples from material of larger dimension, the calculated weight shall be taken as that of the material from which the parts can be cut.

(3) The weight of shop rivets will be computed on the basis of reasonable average lengths, in accordance with the following table:

Rivets 1/2" in diameter.....	20 pounds for 100 rivets
Rivets 5/8" in diameter.....	30 pounds per 100 rivets
Rivets 3/4" in diameter.....	50 pounds per 100 rivets
Rivets 7/8" in diameter.....	100 pounds per 100 rivets
Rivets 1" in diameter	150 pounds per 100 rivets

- Rivets 1-1/8" in diameter 250 pounds per 100 rivets
- Rivets 1-1/4" in diameter 325 pounds per 100 rivets
- (4) Field rivets and bolts will be paid for on the basis of their computed weight.

- (5) To the computed weight of metals may be added 0.4 of 1 percent as an allowance for shop paint.
- (6) The weight of weld metal will be computed on the basis of the theoretical volume of the dimensions of the welds.
- To this weight will be added fifty percent allowance for overrun.

43.13 BASIS OF PAYMENT.

(A) Unit Basis. The poundage, determined as provided above, will be paid for at the contract unit price per pound for structural steel of the type or types specified, which price and payment shall constitute full compensation for furnishing, fabrication, delivering, erecting ready for use and painting all the steel and other metal and for all labor, equipment, tools and incidentals necessary to complete the item.

(B) Lump Sum Basis. The lump sum price for structural steel shall constitute full compensation for furnishing, fabricating, delivering, erecting ready for use and painting of the structural steel and for all labor, equipment, tools and incidentals necessary to complete the item.

The estimate of the weight of structural steel shown on the plans is approximate only and no guarantee is made that it is the correct weight to be furnished. No adjustment in the contract price will be made if the weight furnished is more or less than the estimated weight.

If changes in the work are ordered by the engineer, which vary the weight of steel to be furnished, the lump sum payment will be adjusted as follows:

The value per pound of the increase or decrease in the weight of structural steel involved in the change shall be determined by dividing the contract lump sum amount by the estimate of weight shown on the plans. The adjusted contract lump sum payment shall be the contract lump sum amount plus or minus the value of the steel involved in the change.

Should the ordered change materially alter the character of the work and the unit cost thereof, compensation for such work will be made at an agreed price established prior to the work being performed. The contractor shall provide information detailing changes in procedures and the resulting costs for labor, equipment and materials to fully support the agreed price.

The following percentages of the total quantity of structural steel in place will be allowed for payment on progress estimates:

1. 90% when erected.
2. 97% when bolted or riveted and spot painted.
3. 100% when painted in compliance with the plans and specifications.

NOTES

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SECTION 44

TIMBER STRUCTURES

44.01 DESCRIPTION. Work and materials under this section shall consist of timber structures or the timber portions of composite structures, constructed in conformity with the plans or as ordered in writing, and in accordance with this and other specification items involved.

44.02 MATERIALS. Except when otherwise specified, all material used in this work shall be new and shall conform to the requirements of the sections, specifically referred to as follows:

Untreated Timber Piles	M-270.01
Treated Timber Piles	M-270.02
Structural Timber & Lumber	M-270.03
Treated Timber	M-270.06
Bolts and Nuts	M-290.07
Galvanized Metal	M-290.09
Structural Steel	M-290.02

Drift pins and dowels may be either wrought iron or medium steel. Washers shall be ogee gray iron castings or malleable castings, unless cut washers are specified on the plans. Ring or shear plate timber connectors shall be of approved design and made of noncorrosive metal.

All hardware, except cast iron washer, shall be galvanized or cadmium plated in accordance with ASTM A-165, Type OS.

44.03 CONSTRUCTION DRAWINGS. Drawings shall be prepared showing cutting, framing and boring details, dimensions, size of material, other information and data necessary for fabrication and erection of the treated timber. All shop drawings shall be 22 inches by 36 inches with a 1½ inch margin on the left side and a one half inch margin on the other three sides. Four prints of these drawings shall be submitted to the engineer. Approval shall be secured before cutting and framing begins.

Approval shall only extend to compliance with plans and specifications and shall not relieve the contractor from responsibility for the accuracy of final dimensions and close fit of work.

44.04 CONSTRUCTION METHODS.

(A) Handling of Materials. Treated timber shall be carefully handled

without dropping, breaking of outer fibers, bruising or otherwise penetrating the surface. It shall be handled with rope slings. Cant hooks, dogs, or pike poles shall not be used.

(B) Storage of Materials. Timber stored on the site of the work shall be neatly stacked. The ground underneath and adjacent to material piles shall be cleared of weeds and rubbish. Untreated material shall be open-stacked at least twelve inches above the ground surface. When required material shall be protected from the weather by suitable covering. Treated material shall be close-stacked to prevent warping.

(C) Treatment of Breaks. All places where the surface of treated timber is broken shall be given three brush coats of hot creosote oil or a solution of five percent by weight pentachlorophenol. This treatment shall be followed by one coating of hot tar.

(D) Temporary Attachment. Whenever, with approval, forms or temporary braces are attached to treated timber, with nails or spikes, the holes shall be filled by driving galvanized nails or spikes flush with the surface, or plugging with creosoted plugs after treating with creosote oil.

(E) Bearing. Post and pile caps shall be level and have full even bearing on all posts or piles in the bent and be secured to each pile or post by a three quarter inch diameter drift pin extending at least nine inches into the pile or post at the approximate center thereof.

(F) Sills and Mud Sills. Mud sills shall be firmly and evenly bedded to solid bearing and tamped in place. Sills shall have true and even bearing on mud sills, piles or pedestals. They shall be drift-bolted to mud sills or piles with bolts of not less than three quarter inch diameter and extending into mud sills or piles at least six inches. All earth shall be removed from contact with sills so that there will be free air circulation.

(G) Framing. Timber to be treated with preservatives shall be cut for framing prior to treatment.

Truss and bent timbers shall be accurately cut, and framed to a close fit in such manner that they will have even bearing over the entire contact surface of the joint. No blocking or shimming will be allowed in making joints, nor will open joints be accepted. Mortises shall be true to size for their full depth and tenons shall make snug fit therein.

Cross-bridging between stringers shall be neatly and accurately framed and securely toe-nailed with at least two nails in each end. All cross-bridging members shall have full bearing at each end against the sides of stringers. Unless otherwise specified on the plans cross-bridging shall be placed at the center of each span.

(H) Bolt Holes. Holes for round driftpins and dowels shall be bored with a bit one sixteenth inch smaller in diameter than the pin or dowel to be used. The diameters of holes for square drift-pins or dowels shall be equal to the least dimension of the pin or dowel. Holes for bolts shall be bored with a bit of the same diameter as that of the bolt. Holes for lag screws shall be bored with a bit not larger than the body of the screw at the base of the thread. Holes for rods shall be bored with a bit one sixteenth inch greater in diameter than the rod. All holes bored in treated timber after treatment shall be treated with an approved pressure bolt hole treater. Holes for rods shall be effectively sealed with hot tar or other suitable waterproofing after insertion of rods.

Countersinking shall be done wherever smooth faces are required. Horizontal recesses formed for countersinking shall be painted with hot creosote oil and, after the bolt or screw is in place, shall be filled with hot tar.

(I) Stringer Sizing. Stringers shall be sized at bearing only. Outside stringers shall have butt joint but interior stringers shall be framed to bear over the full width of floor beam or cap at each end. The ends shall be securely fastened to the timber on which they rest. When untreated timbers are used they shall be separated at least one half inch for the circulation of air.

(J) Roadway Floors. Roadway floors shall be of the strip or laminated type and shall be surfaced S1S1E or S4S. Each lamina shall have a nominal thickness of two inches and a width as shown on the plans. It shall be full length except as otherwise permitted on the plans. Unless otherwise specified, they shall be sized to a uniform width and shall not vary in thickness from end to end. Each lamina shall be toe-nailed to alternate stringers with 20d nails and face nailed to adjacent laminae with 20d nails at 18 inch center, staggered. Where splices are permitted, the splice shall be made on the center-line of a stringer and each piece shall be of sufficient length to bear on at least four stringers. Splices shall be made at any one stringer no oftener than every third lamina, and splices in adjacent laminae shall not occur on adjacent stringers. All floors shall be cut to a straight line along the sides of the roadway. Upon written permission, the contractor may adjust the spacing of stringers to reduce wastage in cutting laminated decking from commercial length timbers. Approval of the revised stringer spacings shall be obtained before work is started, but in no case shall the spacing of stringers in the center portion of the roadway exceed 27 inches for 2x4 inch decking.

(K) Surface Treatment of Deck. After laminated decking is laid, and

curbs, with drains as specified, are completed, the entire top surface of deck and the inside surfaces of curbs, shall be treated with three coats of hot tar conforming to ASTM D 490, Grade RT-7 or RT-8 (RT-7 is adapted to cold weather application, RT-8 to warm weather application).

The tar shall be heated in an open tank or kettle to a temperature between 200 degrees F. and 225 degrees F. and then applied evenly to the surfaces to be treated at the rate of one quarter gallon per square yard. Three coats shall be applied at this rate, each coat being given a sufficient time to cool and set up before the application of the succeeding coat is begun.

After the final coat of tar has had sufficient time to cool and set up, and before any vehicles are allowed on the structure, the entire surface of the deck shall be covered with aggregate surfacing at the rate of one cubic yard of material per 24 square yards of surface area. The aggregate surfacing shall conform to the requirements of crushed top surfacing type "A", Grade 2 or 3, or type "B", grade 3, as set forth in Section M-100 except that the amount of material passing the 200-mesh sieve shall not exceed ten per cent.

(L) Wheel Guards. Wheel guards shall be bolted to the outside stringers by three quarter inch machine or hook bolts spaced not more than five feet center to center. All joints shall be lapped. A bolt shall pass through each lapped joint. When the wheel guard is not blocked up from the floor, drain holes shall be provided at such intervals to drain the roadway adequately. Drain holes shall be provided with galvanized iron lining and arranged so as to discharge free of the structure.

(M) Railing. Railing shall be constructed in a workmanlike and substantial manner. Unless otherwise noted, all railing material shall be untreated timber and shall be S4S. All rail shall be squarely jointed at the posts and the rails shall break joint. Nailing of railing to posts will not be permitted.

(N) Nailing. Where nails are to be driven near the end of a piece of timber, it may be necessary to drill holes for nails in order to avoid splitting the piece. The hole shall be drilled smaller in diameter than the nails. Nails shall fit tightly in any drilled hole and only the piece being fastened shall be drilled.

(O) Washers. Washers shall be used between all bolt heads and nuts and the wood, except that carriage bolts, or large-head type timber bolts, shall have washers under nuts only. Cast washers shall have a thickness equal to the diameter of the bolt and a diameter of four times the

thickness. Malleable or plate washers shall have a thickness equal to one half the diameter of the bolt and the length of each side shall be equal to four times the diameter of the bolt. Cast iron washers shall be used when the timber is in contact with earth.

44.05 PAINTING UNTREATED TIMBERS. The surfaces named below shall be thoroughly coated with two coats of hot creosote oil, or a five percent by weight solution of pentachlorophenal, before the timbers are assembled. Ends, tops and all contact surfaces of posts, sills caps, floorbeams and stringers; all ends, joints and contact surfaces of bracing and truss members, all surfaces of timber bumpers, the back face of bulkheads and all other untreated timber which is to be in contact with earth shall be similarly treated.

Unless otherwise specified, untreated timber handrail and posts shall be painted with three coats of paint meeting the requirements of formulas 4 and 8, Article M-280.02. All timber to be painted must be seasoned, and painting shall be done only when the timber is free from frost and the surface is perfectly dry and clean. No painting shall be done in damp or freezing weather. All paints shall be thoroughly dry before applying the succeeding coat. It shall be applied in a good heavy coat, completely covering every part of the surface and shall be worked into the joints and open spaces; it shall be so thoroughly and evenly spread that no excess paint will collect at any point.

METHOD OF MEASUREMENT. Unless otherwise provided, treated timber and untreated timber, complete in place according to the plans and specifications, will be measured separately by the thousand foot board measure. Measurements will be computed from the dimensions shown on the plans, unless changes in such dimensions have been authorized by the engineer. Computations of the amount of lumber and timber in the structure shall be based on nominal sizes and the shortest commercial lengths which could be used. Measurements will include only such timber that is a part of the completed and accepted work, and will not include timber used for erection purposes, such as falsework, forms, bracing, and sheeting.

44.07 BASIS OF PAYMENT. The quantities, determined as provided above, shall be paid for at the contract unit prices per thousand feet board measure, (M.b.m.) for "Untreated Timber" or "Treated Timber" as the case may be, which prices and payments shall constitute full compensation for procuring, furnishing, and delivering all lumber and timber, for any

Art. 44.07

preservative treatment required, for all hardware, and all other metal parts used in the item, for preparing, framing, assembling, erecting, and painting, and for all labor, equipment, tools and incidentals necessary to complete the item.

The cost of all materials, equipment and labor necessary and incidental to the surface treatment of deck, as well as the materials and labor incidental to the construction of the drain openings in curbs, shall be included in the contract price per thousand feet board measure for treated or untreated lumber in place.

SECTION 45

STRUCTURE EXCAVATION

45.01 DESCRIPTION. "Structure Excavation" shall consist of all excavation for foundations for bridges, and all other major structures, and shall include the disposal of material obtained from such excavation and back-filling to the level of the original ground. Unless otherwise specified by the plans or special provisions, it shall also include all necessary bailing, drainage, sheeting, and the construction of shoring and cribs if necessary. The excess material shall be disposed of as directed and in such manner as not to obstruct the stream or otherwise impair the efficiency or appearance of the structure and other parts of the work.

45.02 Classification. All material excavated shall be unclassified and will be paid for as unclassified excavation for structures. The excavation lines and bases of structures shown on the plans shall be considered as approximate only. They may be ordered in writing by the engineer to be placed at any elevation, or of dimensions necessary to give a satisfactory foundation, and no additional compensation will be allowed for such alteration except as provided under Article 45.05.

Boulders, logs, or unforeseen obstacles encountered in excavating shall be removed. No additional compensation will be allowed for driving through or removing such obstructions.

All timber, sheeting, and other material used in making the excavation shall be removed except as ordered. The cost of performing this work shall be considered as included in the contract unit prices for other items of work.

45.03 CONSTRUCTION METHODS.

(A) Depth. All foundation excavation shall be carried to a depth satisfactory to the engineer, regardless of the elevations shown on the plans. Unsuitable material shall be replaced with approved material if required. If rock bottom is secured, the excavation shall be done in a manner to allow the solid rock to be exposed and prepared in horizontal beds. However, for arch substructures, the bottom shall be sloped or stepped as directed. All rock or hardpan foundation surfaces shall be freed from loose or disintegrated pieces, thin strata shall be removed, and the surfaces cut to firm bearing and cleaned to the satisfaction of the engineer.

(B) Treatment of Foundation Materials. Where concrete is to be placed on any excavated surface, special care shall be taken not to disturb the bottom of the excavation more than necessary. The final removal of the material to grade shall not be made until just before the concrete is placed. All seams or crevices shall be cleaned out and filled with concrete mortar. When the excavation is at the required depth, water, if present, shall be pumped out, if possible, for cleaning the foundation bed for inspection. The natural ground adjacent to the structure shall not be disturbed without permission. The existing ground surface at and adjacent to each unit of the substructure shall not be disturbed except as necessary for the sinking of the cofferdams. All excavation shall be restricted to the area inside of the cofferdams, unless otherwise approved.

(C) Cofferdams. Cofferdams or cribs for foundation construction shall, in general, be carried well below the bottom of the footings and shall be well braced and as water-tight as practicable. In general, the interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction of forms and the inspection of their exteriors, and to permit pumping outside of the forms. Cofferdams or cribs which are tilted or moved laterally during the process of sinking shall be righted or enlarged so as to provide the necessary clearance and this shall be at the sole expense of the contractor. Cofferdams shall be constructed so as to protect green concrete against damage from a sudden rising of the stream and to prevent damage to the foundation by erosion. No timber bracing shall be left in cofferdams or cribs in such a way as to extend into the substructure masonry, without written permission.

The contractor shall submit drawings showing his proposed method of cofferdam construction and details left open to his choice when not fully shown on the plans. Such drawings shall be approved before the construction is started, but such approval shall not in any way relieve the contractor of his responsibility to secure a safe and satisfactory cofferdam.

When conditions are encountered which, in the opinion of the engineer, render it impracticable to unwater the foundation before placing masonry or concrete, he may require the construction of a concrete foundation seal of such dimensions as may be necessary. The foundation shall then be pumped out and the balance of the masonry or concrete shall be placed in the dry. When weighted cribs are employed and the weight utilized to partly overcome the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire weight of the crib into the foundation seal. When a foundation seal is placed under water, the cofferdam shall be vented or ported at low water level.

Unless otherwise provided, cofferdams or cribs with all sheeting and bracing shall be removed by the contractor after the completion of the substructure. The removal shall be effected in such a manner as not to disturb or mar the finished masonry.

(D) Pumping. Pumping from the interior of any foundation enclosure shall be done in such manner to preclude the possibility of any portion of the concrete materials being carried away. No pumping will be permitted during the placing of concrete, or for a period of at least 24 hours thereafter, unless it is done from a sump separated from the concrete work by a water-tight wall. Pumping to unwater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure.

(E) Inspection. After each excavation is completed, the contractor shall notify the engineer. No footing shall be placed until the depth of the excavation and the character of the foundation material has been approved.

When required, the contractor shall drill holes or drive rods in the bottom of the footings to ascertain the quality of the material.

(F) Backfilling. All spaces excavated and not occupied by abutments, piers or other permanent work shall be backfilled with earth up to the surface of the surrounding ground, with a sufficient allowance for settlement. Where the backfill is to carry the roadway embankment or any part thereof, the backfill shall be made in continuous horizontal layers not greater than 8 inches in thickness. Each layer shall be compacted by mechanical or hand tamping before the succeeding layer is placed as specified by the applicable provisions of Section 11. All other backfill shall be thoroughly compacted and its top surface shall be neatly graded.

All material used for backfill will be approved before use. It shall be free from large or frozen lumps, wood or other extraneous material. In general, this material shall be selected from the material excavated in connection with the substructure involved. Jetting or ponding of the backfill will not be permitted. Water shall be used to expedite settlement of the backfill only when it is difficult to compact the materials, and ordered by the engineer.

The slope bounding the excavation for abutments and wing walls shall be stepped or serrated to prevent wedge action.

Adequate provision shall be made for thorough drainage of all backfill by placing coarse gravel or broken stone around drain holes in wing and abutment walls as shown on the plans.

For foundations through hard material exposed to erosion, the backfill

around piers and in front of abutments and wings shall be made of the larger and heavier material selected from material removed from the excavation. If acceptable material is not available in sufficient quantity, the engineer may order said backfill to be made of stone or lean concrete; in which case, unless otherwise provided, this backfill shall be paid for as extra work.

No backfill shall be placed against any masonry abutment, wing wall or culvert until permission will have been given, and preferably not until the masonry has been in place 14 days.

The cost of performing this work will be considered as included in the contract unit price for structure excavation for structures.

45.04 METHODS OF MEASUREMENT. Unless otherwise specified structure excavation will be measured and paid for in conformity with the following provisions:

(A) The quantity of structure excavation, Type 1, or Type II, to be paid for at the contract unit price, will be that volume bounded on the sides of vertical planes 18 inches outside of the footing neat lines; on the top by the undisturbed ground surface as it exists at the time excavation is started, or as noted on the plans; and on the bottom to the footing elevation shown on the plans, or to the elevation directed by the engineer not to exceed three feet below plan elevation.

Measurement of structure excavation for tie beams, overhangs, or similar volumes which extend beyond the footing lines, will be 18 inches outside of and below neat lines. The structure excavation so measured shall include only those portions not previously measured or otherwise contained in the volume of footing excavation.

Structure excavation will not be remeasured. The quantity of structure excavation to be measured and paid for will be the quantity computed 18 inches outside the neat lines as described in the two paragraphs above.

(B) Shoring and cribs, unless otherwise specified, will be measured as a lump sum item.

45.05 BASIS OF PAYMENT. Structure excavation will be paid for under the following items.

(A) **Structure Excavation Type I.** Payment will be made at the contract unit price per cubic yard for structure excavation Type I, which price and payment will be full compensation for all necessary pumping, bailing, draining, the construction of all necessary shoring and cribs and for all other work necessary to complete the item, including backfilling over and

around the structure to the original surface of the ground and disposing of all debris and surplus materials.

When it is necessary, in the opinion of the engineer, to carry the foundations below the elevations shown on the plans, the excavation for the first three feet of additional depth will be included in the quantity for which payment will be made under the item "structure excavation."

Excavation below this additional depth will be paid for on the basis of extra work or at the contract price, as the contractor may elect, such choice to be made in writing before work is commenced.

The foregoing provisions shall apply to all increased quantities of excavation resulting from the lowering of bridge footings.

(B) Structure Excavation Type II. Payment will be paid for on the same basis as structure excavation Type I except that shoring and cribs will be paid for on the lump sum basis as specified in par. (C) following.

(C) Shoring and Cribs. Payment for shoring and cribs will be made at the contract lump sum price, which shall be full compensation for the construction and subsequent removal of all shoring and cribs; cofferdams or caissons; and for all material, labor, equipment, tools and incidentals necessary to complete the work.

When it is necessary, in the opinion of the engineer, to carry the foundations below the elevations shown on the plans, no additional compensation over the lump sum price bid for shoring and cribs will be made for increased depth, to an including a depth of three feet below the elevations shown on the plans.

If a depth greater than three feet below the elevations shown is required, allowance for extra cost below the additional three feet depth may be made, based upon the actual cost to the contractor for increasing the height of the cofferdams or cribs or for their reconstruction.

The following percentage of the contract lump sum price for shoring and cribs will be allowed for payment on progress estimates:

1. 65% when shoring and crib is in position.
2. 90% when driven to final elevation.
3. 100% when shoring and crib is removed and the area is cleaned up to the satisfaction of the engineer.

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SECTION 46

PILING

46.01 DESCRIPTION. The work under this section shall consist of furnishing and placing by driving or other means, timber, steel, concrete or other types of pilings in conformity with the plans and specifications or as ordered in writing by the engineer.

46.02 MATERIALS. Except when specified otherwise, all materials shall be new and meet the following requirements:

(A) TIMBER PILING.

1. Untreated Timber Piles. Untreated Timber piles shall conform to the requirements of ASTM D-25, except for tables 1 & 2. The requirement for straightness shall be the same as for Treated Timber Piles. (see following second paragraph).

2. Treated Timber Piles. Treated timber piling shall be either Douglas Fir, Southern Yellow Pine, or Western Larch, conforming to the requirements of ASTM D-25, except for tables 1 & 2. The requirements for straightness shall read:

A straight line from the center of the tip to the center of the butt shall not lie further from the center of the pile at any point more than one percent of the length of the pile for piles up to 75 feet. For piles 75 feet and longer this dimension shall not exceed nine inches. Piles with short or reverse bends or kinks will not be accepted.

Piles shall be seasoned, conditioned and treated in accordance with ASTM D-1760 and AWWA standard specifications for preservative treatment by pressure process.

The preservative shall be creosote oil, creosote coal-tar solution, or a five percent solution of pentachlorophenol, unless specified otherwise.

(B) STEEL PILING

1. Structural Steel Piles. Structural steel piles shall be rolled steel sections of the weight and shape called for on the plans. They shall be structural steel conforming to AASHTO M-183. Piles bent or otherwise damaged will be rejected.

2. Steel Pipe Pile. Steel pipe to be filled with concrete shall conform to the requirements of ASTM A-252, Grade 2. Closure plates for closed end piles shall conform to the requirements of AASHTO M-183.

Steel pipe piles shall be of the diameter and wall thickness shown on the

plans. The wall thickness shall not be less than three-sixteenths of an inch. The pipe, including end closures, shall be of sufficient strength to be driven by the specified methods without distortion.

Closure plates and connecting welds shall not project beyond the perimeter of the pile tips.

(C) CONCRETE PILE.

1. Precast Concrete Pile. Precast concrete piles shall meet the requirements shown on the plans and Sections 40 and 41.

2. Precast Prestressed Concrete Pile. Pre-cast prestressed concrete pile shall meet the requirements shown on the plans and Sections 40 and 42.

(D) PILE SHOES. Pile shoes shall be as called for on the plans or as approved by the engineer.

46.03 TEST PILES. When required, the contractor shall drive test piles of a type and at the location shown on the plans or as directed by the engineer. Test piles shall be driven in one continuous operation to practical refusal with the same type of driving equipment the contractor will use for driving the service piles. The ground at each test pile shall be excavated to plan grade before the pile is driven.

The test piles shall meet the requirements of all pertinent articles of the specifications. They shall be of such length as to provide for the driving of the length shown on the plans below the cutoff elevation.

The contractor shall increase the length shown on the plans, at no cost to the state, the necessary length to reach from the cutoff elevation up to the position of his driving equipment, but not less than two feet for timber piles and not less than one foot for other piles. The required minimum increase in pile lengths shall become the property of the state.

Test piles shall be driven so that they may be utilized as a service pile in the completed structure.

Unless otherwise noted on the plans or in the Special Provisions, test piles will not be required to establish the furnished lengths of steel bearing piles and an itemized list will not be furnished by the engineer.

46.04 LOAD TESTS. When required, the contractor shall make load tests on test piles.

46.05 FURNISHING PILING. Except as otherwise specified on the plans or in the special provisions, all piling shall be ordered by the contractor in

agreement with an itemized list which will be furnished by the engineer after the test piles for a particular substructure unit have been driven. The list will show the number, type and length of piles required, and will be based on information secured from driving test piles.

The length shown on the list will be the lengths required below cutoff and the contractor shall increase these lengths, at no cost to the state, the necessary length to reach from the cutoff elevation up to the position of his driving equipment, but not less than two feet for timber piles and not less than one foot for other piles. The required minimum increase in pile lengths shall become the property of the state.

When steel bearing piles are called for and test piles are not required, the number of linear feet furnished to be measured for payment will be the total footage complete in place and accepted.

All timber piling shall have a diameter at the tip and at a section three feet from the butt indicated for the length of piling shown on the engineer's order list, in conformity with the following table:

Circumferences and Diameters of Timber Piles

Length	3 feet from butt				At tip, minimum	
	Minimum		Maximum		Circum- ference	Diameter (approx- imate)
	Circum- ference	Diameter (approx- imate)	Circum- ference	Diameter (approx- imate)		
Feet	Inches	Inches	Inches	Inches	Inches	Inches
Douglas Fir, Hemlock, Larch, Pine, Spruce or Tamarack						
Under 40	38	12	63	20	25	8
40 to 50 incl..	38	12	63	20	22	7
51 to 70 incl..	41	13	63	20	22	7
71 to 90 incl..	41	13	63	20	19	6
Over 90 ¹	- -	- -	- -	- -	- -	- -

¹ Dimensions of piles over 90 feet in length shall be as given in the special provisions.

46.06 DRIVING PILING.

(A) General. All piling furnished in accordance with Article 46.05 shall be driven to the length set below cutoff or to the specified penetration or to practical refusal unless otherwise approved by the engineer.

The pile bearing requirements shown on the plans are based on design loadings and indicate the loads which the piles are required to support. The pile bearings, computed using the formulas defined in Article 46.06

(B) are approximations only, and driving shall continue beyond these bearings until the required penetration is reached, or until the pile has been driven to practical refusal. Each service pile shall be driven in one continuous operation. In the event the driving equipment breaks down the contractor shall exert every reasonable effort to resume driving with the least possible delay.

Unless noted otherwise on the plans, in the Special Provisions, or changed by the Construction Bureau, minimum pile penetrations shall be as follows:

Footings in natural ground-ten feet below bottom of footing elevation.

Footings in embankments-ten feet below natural ground.

When piling cannot be driven practically to the required penetration by means of the pile hammer alone, hard driving procedures may be required, a lesser penetration may accepted, or-after review of structural and field conditions, the foundation may be re-designed if determined necessary.

Piling furnished shall be driven in strict agreement with the lines and spacing shown on the plans and within an allowed variation as to direction of pile of $\frac{1}{4}$ inch per foot of pile length.

The character of the soil, penetration, conditions of driving, distribution, size, length and weight of piles shall be taken into consideration in determining the safe bearing value.

In no case shall the safe bearing value be less than the design load shown on the plans unless otherwise approved by the engineer.

During the course of driving if it should become apparent that the required bearing values cannot be obtained, the work shall be stopped when the pile is driven to approximately two feet above cut off elevation. After a setup period of not less than "24" hours nor more than "72" hours, driving shall be resumed and bearing values calculated for each blow up to five blows. In no case shall the pile be driven below a sound cutoff elevation.

No extra compensation shall be considered or allowed for redriving required by the engineer.

(B) Timber Piling. Treated and untreated timber piles shall be driven with a steam or air or diesel hammer developing not less than 12,000 ft. lbs. of energy per blow.

When not driven to practical refusal, the safe bearing values for timber piles will be determined by the following formulae:

For single acting steam hammers, air hammers and diesel hammers:

$$P = \frac{2WH}{S + 0.1}$$

double acting steam or air hammers

$$P = \frac{2H (W + Ap)}{S + 0.1}$$

Where P—safe load per pile in pounds,

W—weight in pounds of striking part of hammer,

H—height of fall in feet,

A—area of piston in square inches,

p—steam or air pressure in pounds per square inch at hammer

S—the average penetration in inches per blow for the last 10 to 20 blows of the hammers.

Note: The term "WH" in above formulas shall be determined by the engineer.

These formulas are applicable only when

- (a) The hammer is operating normally.
- (b) The penetration is at a reasonably quick and uniform rate.
- (c) The head of the pile is not broomed or crushed.
- (d) A follower is not used.

(C) Steel Piles. Steel H piles and steel pipe shall be driven with either a steam or air or diesel hammer which develops not less than 12,000 ft. lbs. of energy per blow, and shall be driven to practical refusal except as otherwise directed by the engineer.

When not driven to practical refusal, the safe bearing value for steel piles may be approximated by the formulas specified for timber piles.

(D) Precast Concrete and Prestressed Precast Concrete Piles. Unless otherwise provided, precast concrete and prestressed precast concrete piles shall be driven with either a steam or air or diesel hammer which develops one foot-pound of energy per blow for each pound of weight driven, but not less than 12,000 foot pounds of energy per blow. All concrete piles shall be driven to practical refusal except as otherwise directed by the engineer.

When not driven to practical refusal, the safe bearing value for concrete piles may be approximated by the formulas specified for timber piles.

46.07 INSPECTION. Untreated timber piles will be inspected at the site of the work by the engineer.

Treated timber piles will be inspected at the treating plant before treatment, for grade and suitability by an inspector designated by the

engineer. The inspector will stamp each pile on the butt end with a stamp which will make an impression that is readily legible after treatment. The stamp shall be copyrighted by the inspector and a true impression filed with the department. After treatment the piles will again be inspected. The inspector will stamp each pile on the butt end with a stamp differing from that used before treatment, and of which a true impression has also been filed.

The inspector shall file an itemized report of all piles inspected, giving temperatures, quantity of preservative, time of treatment, lengths and sizes, total footage, and any other pertinent information. Treated timber piles which do not bear the stamps of the inspector made both before and after treatment shall not be shipped from the plant.

Steel piles may be inspected at the rolling mill by an inspector designated by the engineer. Whether inspected or not, the contractor is required to furnish the engineer two copies of the certified mill test reports depicting the chemical and physical test results for each heat number of steel piles in the shipment. The steel piles will be inspected at the job site by the engineer. Camber and sweep of steel piles shall not exceed that permitted by allowable mill tolerances. Piles bent or otherwise injured in shipment will be rejected.

Concrete piles will be inspected at the fabricating plant by an inspector designated by the engineer and at the job site by the engineer.

46.08 CONSTRUCTION METHODS

(A) Excavation. In general, piles shall not be driven until after the excavation is complete. Material forced up between the piles shall be removed to correct elevation without cost to the state before concrete for the foundation is placed.

(B) Caps. The heads of all concrete piles, and the heads of timber piles, when the nature of the driving is such as to unduly injure them, shall be protected by caps of approved design, preferably having a rope or other suitable cushion next to the pile head and fitting into a casting which in turn supports a timber shock block. When the area of the head of any timber pile is greater than that of the face of the hammer, a suitable cap shall be provided.

For special types of piling, driving heads, mandrels, or other devices conforming to the manufacturers' recommendation shall be provided.

For steel piling the heads shall be cut squarely and a driving cap shall be provided. The axis of the pile shall be held in line with the axis of the hammer.

(C) **Collars.** Collars, bands, or other devices may be required.

(D) **Pointing.** Timber piles shall be pointed where soil conditions require it. When necessary, the piles shall be shod with metal shoes of a design satisfactory to the engineer, the points of the piles being carefully shaped.

(E) **Splicing Piles.** Full length piles shall be used where practicable. In exceptional circumstances splicing of piles may be permitted or required. When the splicing of steel piles or steel shells of special piles is required, all welding shall conform to the plans and special provisions.

(F) **Hard Driving Procedures.** Hard driving shall be defined as sustained driving beyond practical refusal to the point that pile damage is likely imminent and necessitates methods other than the use of the pile hammer only to obtain required penetration in natural ground. Practical refusal will be determined by the Engineer who will take into consideration the type and size of piling, soil conditions and the type and size of the pile hammer. Generally, practical refusal is considered to be a penetration of one inch to one-half inch per ten blows for wood piles, and from three-quarters inch to one-quarter inch per ten blows for steel piles. Sustained driving will be considered to be driving for more than two feet of penetration at blow counts in excess of those stated above.

When determined necessary by the Engineer, and approved by the Construction Bureau, hard driving procedures shall be employed. These procedures may include pile shoes and pile reinforcement, drilling and shooting, pre-boring, jetting, punching, use of a different type or size of pile hammer, or employing other measures as necessary to secure the required penetration without damage to the pile.

(G). **Leads.** Pile driver leads, guying or bracing of piles and pile drivers shall provide freedom of movement of the hammer and shall hold the hammer or pile or both in the proper vertical or inclined position throughout the driving operation. Guying and/or bracing of pile driver leads and piles which do not hold the hammer or pile or both in the proper vertical or inclined position throughout the driving operation, shall be sufficient reason to stop pile driving operations until suitable fixed leads or other approved methods are provided.

(H) **Followers.** Driving piling with followers shall be avoided and shall be done only with written permission of the engineer. When the contractor requests the use of a follower, he shall submit detailed drawings of the proposed equipment. If a follower is used, one pile from each group of ten

shall be a long pile driven without a follower, and shall be used as a test pile.

(I) Water Jets. When water jets are used, the number of jets and the volume and pressure of water at the jet nozzles shall be sufficient to freely erode the material adjacent to the pile. The plant shall have sufficient capacity to deliver at all times at least 100 pounds per square inch pressure at each two three-quarter-inch jet nozzles. Before the desired penetration is reached, the jets shall be withdrawn and the piles shall be driven with the hammer to secure the final penetration.

(J) Prebore Holes. Prebore holes for piles shall be used only when specified on the plans.

The hole shall have a diameter of not less than the butt diameter of the pile plus six inches. After driving the pile the space around the pile shall be filled to ground surface with dry sand or pea gravel.

(K) Defective Piles. The method used in driving piles shall not subject them to excessive and undue abuse producing crushing and spalling of the concrete, injurious splitting, splintering, and brooming of the wood, or deformation of the steel. Manipulation of piles to force them into proper position, if considered by the engineer to be excessive, will not be permitted. Any pile damage in driving by reason of internal defects, improper driving, driven out of proper location, or driven below the elevation fixed by the plans or by the engineer, shall be corrected at the contractor's expense by methods approved by the engineer for the pile in question.

A concrete pile shall be considered defective if it has a visible crack, or cracks, extending around the perimeter of the pile, or any defect which, in the opinion of the engineer, may affect the strength or life of the pile.

(L) Storage and Handling of Timber Piles. The method of storing and handling shall avoid injury to piles. Special care shall be taken to avoid breaking the surface of treated piles. Cant hooks, dogs or pike poles shall not be used. Cuts or breaks in the surface of treated piling shall be given three brush coats of hot creosote oil of approved quality, and hot creosote oil shall be poured into all bolt holes.

(M) Cutting Off Timber Piles. The tops of all piling shall be sawed to a true plane, as shown on the plans, and at the elevation fixed by the engineer. Piles which support timber caps or grillage shall be sawed to conform to the plane of the bottom of the superimposed structure. In general, the length of pile above the elevation of cutoff shall be sufficient to permit the complete removal of all material injured by driving, but piles

driven to very nearly the cut-off elevation shall be carefully adzed or otherwise freed from all broomed, splintered, or injured material.

After cut-off, the heads of all treated timber piles shall be given three coats of hot creosote oil or three coats of a five percent solution of pentachlorophenol.

All pile cut-offs ten feet or greater in length shall become the property of the state and shall be neatly stored in designated locations within the right of way. Cut-offs that do not meet the above requirements shall be disposed of by the contractor in a manner satisfactory to the engineer.

(N) Cutting off Steel or Steel Pipe Piles. Piles shall be cut off at the required elevation. If capping is required, the connection shall be made according to details shown on the plans.

When steel piling is furnished in agreement with the "engineer itemized order list," all pile cut-offs five feet or greater in length shall be neatly stored in designated locations within the right of way. Cut-offs that do not meet the above requirements shall be disposed of by the contractor in a manner satisfactory to the engineer.

(O) Cutting Off Precast Concrete or Precast Prestressed Concrete Piles. Precast concrete or precast prestressed concrete piles shall be cut off at required elevation. If capping is required, the connection shall be made in agreement with details shown on the plans. All concrete pile cutoffs shall become the property of the contractor and shall be disposed of in a manner satisfactory to the engineer.

(P) Piles Cast in Place. Piles shall be constructed in accordance with details shown on the plans.

At all times prior to the placing of concrete in the driven steel pipe piles, the contractor shall have available a suitable light for the inspection of each pile throughout its length. Any improperly driven, broken or otherwise defective pile shall be corrected to the satisfaction of the engineer, by removal and replacement, or the driving of an additional pile, at no extra cost to the Department.

Accumulations of water in steel pipe piling shall be removed before the concrete is placed. No concrete shall be placed until all driving within a radius of 15 feet has been completed, nor until all the piling for any one bent has been completely driven. If this cannot be done, all driving within the above limits shall be discontinued until the concrete in the last pile cast has set at least seven days.

(Q) Extensions or Build-Ups. Extensions, splices or "build-ups" on precast concrete or precast prestressed concrete piles, when necessary, shall be made as follows:

After the driving is completed, the concrete at the end of the pile shall be cut away, leaving the reinforcing steel exposed for a length of 40 diameters. The final cut of the concrete shall be perpendicular to the axis of the pile. Reinforcement similar to that used in the pile shall be securely fastened to the projecting steel and the necessary formwork shall be placed, care being taken to prevent leakage along the pile. The concrete shall be of the same quality as that used in the pile. Just prior to placing concrete the top of the pile shall be thoroughly wetted and covered with a thin coating of neat cement, or other suitable bonding material. The forms shall remain in place not less than seven days and shall be carefully removed and the entire exposed surface of the pile finished to match the original pile.

Extensions of steel piles shall be constructed by splicing on additional sections of steel piling. Splices shall be made by means of single-V butt-welds which will develop the section of the pile or by other means acceptable to the engineer.

Splices in precast prestressed piles shall be made as noted on the plans.

(R) Painting Steel Piles and Steel Pile Shells. Unless otherwise provided, when steel piles or steel pile shells extend above the ground surface or water surface, they shall be protected by three coats of paint meeting the requirements of Section 91.06(B), or as set forth in the special provisions.

This protection shall extend from an elevation two feet below the water or ground surface to the top of the exposed steel.

46.09 METHOD OF MEASUREMENT.

(A) Measurement. Unless otherwise noted in the special provision, piling will be measured under the following items:

1. Test piles—Lump sum
2. Load tests—Each
3. Furnishing piles—Linear foot
4. Driving piles—Linear foot
5. Preboring holes for piles—Linear foot
6. Pile splices—Each
7. Pile shoes—Each
8. Extensions or build-up—Linear foot
9. Filler concrete—Cubic yard
10. Piles—Each
11. Hard Driving—Linear foot (force account basis only)

(B) Test Piles. The number of test piles to be paid for shall be the number shown on the plans, except should the number of test piles set forth be increased or decreased, the lump sum price bid for test piles shall be increased or decreased by the following formula:

$(a \times c) + (b \times d)$ Where:

a=Length of test pile required below cutoff elevation

b="a" minus footing embedment

c=Unit price bid for furnishing piling

d=Unit price bid for driving piling

(C) Load Tests. The number of load tests to be paid for shall be the number of load tests made, completed, and accepted.

(D) Furnish. The number of linear feet furnished to be measured for payment will be the total footage computed from the engineer's order list, or in agreement with Article 46.05.

(E) Driving. The number of linear feet to be measured for payment will be the linear feet of piling driven into the ground below the bottom of the sub-structure units, or below the bottom of pre-bore holes when pre-boring is required.

(F) Preboring Holes For Piling. The number of linear feet to be measured for payment will be the number of linear feet drilled below the bottom of the substructure units.

(G) Pile Splices. The number of splices to be measured for payment will be the number of pile splices shown on the plans. If the engineer permits splicing piling solely for the contractor's convenience to meet order list lengths, to suit driving conditions, or for other reasons, such splicing will not be measured for payment.

(H) Pile Shoes. The number to be measured for payment will be the total number shown on the plans or authorized by the engineer.

(I) Extensions or Build-ups. The number of linear feet to be measured for payment will be the total number of linear feet as shown on the plans or as ordered in writing by the engineer.

(J) Hard Driving. The number of linear feet to be measured will be the linear feet of piling driven into natural ground using hard driving procedures as described in Article 46.08 (F). Penetration of hard layers, two feet or less in thickness, by use of the pile hammer alone will not be measured for payment as hard driving but will be measured in accordance with the provisions of Article 46.09 (E).

46.10 BASIS OF PAYMENT

(A) Furnishing. Payment for furnishing piling, when made at the contract unit price per foot will include full compensation for furnishing the piling and all material required therefore ready for placement, and for all labor, tools, hauling, equipment, handling, treatment and all other work incidental to the construction of the piling prior to driving. Payment will also include reinforcement in precast concrete piles and precast prestressed concrete piles and the furnishing and attachment of brackets, lugs, core stoppers, tip reinforcements, and cap plates on steel piling.

(B) Driving. Payment for driving piles at the contract unit price per foot will include full compensation for furnishing all labor, tools, materials, supplies, equipment and other necessary or incidental costs of handling, driving, cutting off piles, treatment and capping of pile heads painting steel piles and all other incidental work connected therewith. The splicing of piles will be paid for as provided in paragraph (C).

(C) Pile Splices. Payment for pile splices at the contract unit price per each will include full compensation for furnishing all labor, tools, equipment, materials and all other incidental work necessary to complete the splice.

(D) Extensions or build-ups. Payment at the contract unit price per linear foot for extensions or build-ups will include full compensation for furnishing all labor, tools, materials, supplies, equipment and other necessary or incidental work necessary to complete the extensions or build-ups.

(E) Filler Concrete. Payment at the contract unit price per cubic yard for filler concrete will include full compensation for furnishing all labor, tools, materials, supplies, equipment and other incidental work necessary to furnish and place the concrete.

(F) Timber Pile Shoes. Payment for timber pile shoes at the contract unit price per each will include full compensation for furnishing all labor, tools, equipment, materials and all other incidental work necessary to furnish and place the shoe on the pile.

(G) Load Tests. Payment for each load test at the contract price will include full compensation for the cost of all materials, tools, equipment and labor necessary to make each load test as directed by the engineer, or as specified in the special provisions.

(H) Test Piles. Payment for test piles at the contract lump sum price will include the cost of all materials, tools, equipment, and labor necessary to complete the work.

(I) Preboring Holes for Piles. Payment for preboring holes for piles when made at the contract unit price per foot will include the cost of all materials, tools, equipment and labor necessary to drill the holes, and after driving the piles, to fill in the space around the piles with sand or pea gravel.

(J) Piles. Payment for piles at the contract unit price for each pile will be full compensation for furnishing and driving the pile. It will also include full compensation for cutting off piles, treatment and capping of pile heads, painting steel pile and jetting, drilling, blasting or other work necessary to obtain the required penetration or bearing value, and for all other incidental work connected therewith.

(K) Falsework and Defective Piles. No payment will be made for the furnishing or driving of falsework piles, nor will payment be made for piles driven out of place, for defective piles, or for piles which are damaged in handling or driving.

(L) Additional Requirements. If the length of wood piles, steel piles or steel pile shells designated by the engineer is not sufficient, the splicing, including labor, equipment and material, will be paid for on the basis of extra work unless a contract item is provided to cover the payment.

Brackets, plates or other reinforcement on steel piles required by the engineer in addition to those shown on the plans will be paid for as extra work.

If not covered by a contract item, metal shoes for piling, ordered by the engineer, will be paid for at cost delivered to the site, plus 15 percent.

No separate payment will be made for painting exposed portions of steel piles or steel pile shells.

No additional allowance, or adjustment, will be made in the contract price for furnishing or driving piling because of these additional requirements.

(M) Hard Driving. Payment for hard driving will be at the contract unit price per foot for driving or on an agreed price or force account basis as provided in Article 09.04. Payment shall be full compensation for furnishing all labor, tools, materials, supplies, equipment and other necessary or incidental costs such as pile shoes and reinforcement, drilling and blasting, preboring, jetting, punching, providing a different size or type of pile hammer, and other measures necessary to secure the required penetration.

(N) Piles Ordered and Not Driven. Piling purchased in accordance with the engineer's itemized list but not incorporated in the finished struc-

ture shall be immediately delivered to the state and shall become the property of the state.

(O) Partial Payment. The following percentages of the total quantity of piles driven, for the various types of piling, will be allowed for payment on progress estimates:

1. 95% when driven to final penetration.
2. 100% when cut off in compliance with the plans and specifications.

SECTION 47

REINFORCING STEEL

47.01 DESCRIPTION. "Reinforcing Steel" shall consist of furnishing and placing reinforcing steel or wire fabric of the quality, type and size designated, meeting the requirements of the plans and specifications, or as ordered in writing.

47.02 MATERIAL. Except when otherwise specified, all material used in this work shall be new and shall conform to the requirements of Section M-290. Specific references are made as follows:

Reinforcing Steel	M-290.01 (A)
Wire and Wire Mesh	M-290.01 (B)

47.03 PROTECTION OF MATERIAL. Steel reinforcement shall be protected at all times from injury. When placed in the work, it shall be free from dirt, detrimental scale, paint, oil and other foreign substance. When steel reinforcement has detrimental rust, loose scale and dust which is easily removable, it shall be cleaned by a satisfactory method, if approved.

47.04 FABRICATION. Bar reinforcement shall be bent to the shapes shown on the plans.

All bars shall be bent cold, unless otherwise permitted. No bars partially imbedded in concrete shall be field bent except as shown on the plans or otherwise permitted.

The radii of bend measured on the inside of the bar for standard hooks shall be not less than the following:

Bar Size	Minimum Radii
3 thru 8	3 bar diameters
9 thru 11	4 bar diameters
14S or 18S	5 bar diameters

Written permission must be obtained from the engineer prior to special fabrication or bends exceeding 90 degrees for No's. 14S and 18S steel.

Bends for stirrups and ties shall have radii on the inside of the bar not less than one bar diameter. Bends for all other bars shall have radii on the inside of the bar not less than the values tabulated in the preceding paragraphs.

Bar reinforcement shall be shipped in standard bundles, tagged and

marked in accordance with the Code of Standard Practice of the Concrete Reinforcement Steel Institute.

Fabrication drawings need not be submitted unless specifically requested.

47.05 PLACING AND FASTENING. All steel reinforcement shall be accurately placed in the positions shown on the plans and firmly held during the placing and setting of the concrete. Bars shall be tied at all intersections except where spacing is less than one foot in each direction when alternate intersections shall be tied.

Distance from forms shall be maintained by means of stays, ties, hangers, approved metal chairs, blocks or other approved supports. Blocks shall be precast mortar of the proper dimension and shall be provided with an embedded wire for fastening to bar reinforcement. Blocks shall be cast from concrete of the approved mix design in use on the project and shall be water cured for a period of not less than seven (7) days prior to their use. Layers of bars shall be separated by precast mortar blocks, upper continuous metal chairs or other equally suitable approved devices. Precast mortar blocks may be used at all locations approved by the engineer except that they shall not be used to support bridge deck slab reinforcing steel.

For slabs, metal chairs, of the "Upper Continuous High Chair, (U.C.H.C.)" designation shall be used to separate the top and bottom mats of reinforcing steel. In bridge construction, the upper continuous bar supports shall be placed at right angles to centerline of structure for "Flat Slab" structures and parallel to centerline of structure for all other deck slab construction. The use of pebbles, pieces of broken stone, concrete rubble, broken brick or building blocks, metal pipe, or wooden blocks will not be permitted.

Reinforcement in any member shall be placed, inspected and approved by the engineer before the placing of concrete begins. Concrete placed in violation of this provision may be rejected and its removal required.

If fabric reinforcement is shipped in rolls, it shall be straightened into flat sheets before being placed.

47.06 SPLICING REINFORCEMENT. All reinforcement shall be furnished in the full lengths indicated on the plans. Splicing of bars, except where shown on the plans, will not be permitted without written approval.

47.07 REINFORCING STEEL, MATERIAL GUARANTY & RANDOM

SAMPLING. For each shipment of reinforcing steel delivered to the project, the contractor shall furnish duplicate copies of the following:

1. Shipping invoice which shows the weight and price per pound of all of the steel in the shipment.

2. Certified mill test reports showing physical and chemical analysis on each heat of reinforcing steel included in the shipment.

3. A statement from the fabricator which certifies that the mill tests furnished are representative of the reinforcing steel furnished.

A shipment shall consist of the entire amount of reinforcing steel in each truck load delivered to the project. When delivery is made by railroad, each 20 tons or fraction thereof shall be considered a shipment.

The State will make whatever tests are deemed necessary to ascertain the quality of the material furnished. The contractor shall obtain the samples as directed by the engineer. The material lists shown on the plans will usually contain sufficient reinforcing steel for the tests; however, it shall be the contractor's responsibility to furnish at no cost to the State whatever additional reinforcing steel is required for testing.

In the event that a sample of reinforcing steel fails the tests, two additional check samples representing the sample that failed will be tested. If either of the check samples fail, the steel in the shipment represented by the failing sample may be rejected, or if the Chief - Bridge Bureau determines that the steel is usable, a penalty will be assessed against the contractor. The penalty will be calculated using the following formula:

$$P = A \times B$$

A = Total invoice price of reinforcing steel in the shipment.

B = 10%, 20% or 30% dependent upon departure from specifications.

The value to be used shall be determined by the Chief - Bridge Bureau.

P = Penalty for the shipment.

The amount of the penalty as calculated above will be deducted from any money due the contractor on the final estimate.

All steel rejected by reason of failures of the random tests shall be removed and replaced by the contractor at no additional cost to the State. Invoice statements, mill reports and fabrication certificates will be required for replacement steel which will also be subject to random tests as specified above.

No reinforcing steel in a shipment which has been sampled will be finally accepted until the results of the random tests on the shipment are known. Prior to testing, the contractor may proceed with the work at his own risk.

No extra compensation will be considered or allowed by reason of the conditions of this provision as it shall be considered necessary and incidental to the completion of the work.

47.08 METHOD OF MEASUREMENT. Reinforcing steel will be measured by the pound based on the calculated theoretical weight of the steel as shown on the plans or as ordered in writing complete in place, and accepted. The weights of standard sizes of reinforcing bars, conforming to AASHTO M-31, shall be computed in accordance with the following table:

No. 3 Bars.....	.376 Lbs. Per Foot
No. 4 Bars.....	.668 Lbs. Per Foot
No. 5 Bars.....	1.043 Lbs. Per Foot
No. 6 Bars.....	1.502 Lbs. Per Foot
No. 7 Bars.....	2.044 Lbs. Per Foot
No. 8 Bars.....	2.670 Lbs. Per Foot
No. 9 Bars.....	3.400 Lbs. Per Foot
No. 10 Bars.....	4.303 Lbs. Per Foot
No. 11 Bars.....	5.313 Lbs. Per Foot
No. 14 Bars.....	7.650 Lbs. Per Foot
No. 18 Bars.....	13.600 Lbs. Per Foot

If reinforcing bars other than standard sizes, or wire fabric are required, the unit weight will be shown on the plans.

The estimated quantities of bar reinforcing steel required for the bridge work shall be considered as approximate only and no guarantee is made that the quantities which can be determined by computations, based on the details and dimensions shown on the plans, will equal the estimated quantities. No allowance will be made in the event the quantities based on these computations do not equal the estimated quantities.

47.09 BASIS OF PAYMENT. The poundage, determined as provided above, shall be paid for at the contract unit price for reinforcing steel complete in place, which price shall be full compensation for the work. No allowance will be made for clips, wire, separators, or other material used for fastening or supporting the reinforcing steel in place.

The following percentages of the total quantity of Reinforcing Steel in place will be allowed for payment on progress estimates:

1. 85% when placed and tied.
2. 90% when covered with concrete.
3. 100% when random tests are complete and material accepted.

SECTION 48

STEEL BRIDGE RAILING

48.01 DESCRIPTION. This work shall consist of furnishing and installing steel bridge railing.

48.02. FABRICATION DRAWINGS. Fabrication drawings for steel bridge railing shall meet the requirements of Article 43.03.

48.03 MATERIALS. Unless otherwise specified, all materials used in this work shall be new and shall meet the requirements of Section M-290. Specified references are made as follows:

Steel Pipe	M-320.01(D)(2)(c)
High Tensile Strength Anchor Bolts	M-290.06
Galvanized Metal	M-290.09
Structural Steel	M-290.02

48.04 FABRICATION. Fabrication of steel bridge railing shall meet the requirements of the applicable portions of Section 43, "Steel Structures."

48.05 ERECTION. Steel bridge railing shall be constructed to the line and grade shown on the plans and shall not reflect any unevenness in the structure. Unless otherwise specified, all railing posts shall be vertical. Railing shall not be placed on a span until centering or falsework has been removed, rendering the span self-supporting.

Steel pipe to be used as railing shall conform to the requirements of ASTM A-53, Type E or S, Grade B.

48.06 PAINTING. Steel bridge railing shall be cleaned and painted in conformity with the provisions in Section 91, "Painting."

48.07 METHOD OF MEASUREMENT. The quantity to be paid for under this item shall be the number of linear feet of bridge railing of the several types, complete in place and accepted, measured along the line and grade of the railing from center line to center line of end base plates. It shall include all work constructed above the top of the curb and all fastenings and anchors required to attach the railing to the structure.

48.08 BASIS OF PAYMENT. Payment for steel bridge railing at the con-

tract unit price per linear foot shall include full compensation for the cost of all materials, tools, equipment and labor necessary to complete the work.

The following percentages of the total linear footage of Steel Bridge Rail in place will be allowed for payment on progress estimates:

1. 90% when erected.
2. 95% when bolted and spot painted.
3. 100% when painted in compliance with the plans and specifications.

SECTION 49

MISCELLANEOUS

STRUCTURE ITEMS

49.01 DESCRIPTION. This section shall pertain to the furnishing and installation of bridge drains, drainage systems and damp-proofing, and other miscellaneous items enumerated or as may be added. Materials and procedures shall meet the provisions of this or other pertinent sections of the specifications, to the plans or standard drawings or as may be especially provided or directed.

49.02 FABRICATION DRAWINGS. Fabrication drawings for bridge drains and drainage systems shall comply with Article 43.03.

49.03 MATERIALS. Except as otherwise specified, all materials used in this work shall be new and shall meet to the requirements of the specific reference as follows:

Structural Steel	M-290.02
Steel Pipe	M-170.07
Corrugated Galvanized Metal Pipe	M-170.02
Corrugated Asbestos Sheets	ASTM C-221
Asphalt Plank	ASTM D-517
Coal-tar Waterproofing	ASTM D-450

49.04 CONSTRUCTION METHODS.

(A) Bridge Drains. Bridge drains shall be fabricated in compliance with the plans and the applicable provisions of Section 43. Galvanizing shall be done after all welding is completed.

(B) Drainage System. Drainage systems for bridges shall be fabricated in compliance with the plans the applicable provision of Section 43.

(C) Damp-proofing. Damp-proofing shall not be applied when the atmospheric temperature is below 50 degrees F. without written permission. Surface to be damp-proofed shall be dry and clean and no coat shall be applied when in the opinion of the engineer the weather is unsuitable.

49.05 METHOD OF MEASUREMENT.

(A) The number of bridge drains to be paid for shall be the actual number completed and acceptably installed.

(B) **Drainage System.** Drainage systems shall be paid for on a lump sum basis.

(C) **Damp-proofing.** The number of square yards to be paid for shall be computed from the dimensions shown on the plans or as ordered in writing.

49.06 BASIS OF PAYMENT.

(A) **Bridge Drains.** The contract unit price per each for bridge drains shall include full compensation for furnishing all material, tools, equipment and labor necessary to complete the work.

(B) **Drainage System.** The contract lump sum price for drainage system shall include full compensation for furnishing all materials, tools, equipment and labor necessary to complete the work.

(C) **Damp-proofing.** The contract unit price per square yard for damp-proofing shall be full compensation for all materials, tools, equipment and labor necessary to complete the work.

SECTION 50

SLOPE AND BANK PROTECTION

SUBSECTION 50.10 RIPRAP

50.11 DESCRIPTION. Riprap shall consist of a revetment composed of stone, fragmented rock, concrete or sacked concrete, placed as a protective covering, along the slopes of embankments, around culvert inlets or outlets, foundations, bridge berms, dykes or at places as may be directed in conformity with the plans and specifications.

50.12 HAND LAID AND RANDOM RIPRAP

A. Material.

1. General. Stone shall be hard, durable, angular in shape, resistant to weathering and to water action; free from overburden, spoil, shale, structural defects, and organic material; and shall meet the gradation requirements for the class specified. Neither breadth nor thickness of a single stone should be less than one-third its length. Rounded stone or boulders will not be accepted unless authorized by the engineer. Shale or stone with shale seams is not acceptable.

The acceptability of the stone will be determined by previous use records or by tests the engineer determines appropriate. If testing is required, suitable samples of stone taken in the presence of the engineer shall be submitted, by the contractor, at least 30 days before beginning the placing of riprap. Control of gradation will be by visual inspection.

2. Hand Laid Riprap. Each stone or fragment shall not be less than three inches thick nor contain less than one-half cubic foot in volume nor weigh less than 75 pounds, except for rock spalls. All stones and fragments shall extend through the revetment with the exception of spalls used to chock the larger stones solidly in position and to substantially fill voids between the major stones.

3. Random Riprap. The gradation of random riprap shall conform to the following:

	Weight of Stone	Equivalent Spherical Diameter*	Percent of Total Weight That Must be Smaller than Given Size
CLASS I:	100 lb.	1.05 ft.	100%
	60 lb.	.88 ft.	90-70
	25 lb.	.66 ft.	60-40
	2 lb.	.27 ft.	0-10
CLASS II:	700 lb.	2.00 ft.	100%
	500 lb.	1.79 ft.	90-70
	200 lb.	1.32 ft.	60-40
	20 lb.	.61 ft.	0-10
CLASS III:	2000 lb.	2.82 ft.	100%
	1400 lb.	2.53 ft.	90-70
	700 lb.	2.00 ft.	60-40
	40 lb.	.77 ft.	0.10

*Based on unit weight of 165 lbs/ft³

(B) Construction Methods.

(1) **Hand Laid Riprap.** A trench of the design and dimensions shown on the plans or as directed shall be excavated along the toe of the slope to a stable foundation or carried to a point below scour, but in no case less than two feet below the toe of the slope and a course of the largest stone placed therein. The slope to be protected shall not be steeper than the angle of repose of the material, unless otherwise directed. The stones shall be placed with their beds at right angles to the slope and so far as practicable the larger stones shall be used in the lower courses. They shall be laid in close contact so as to break joints and so placed that each stone will rest on the slope of the embankment and not wholly on the stone beneath it. The spaces between the stones shall be filled with smaller stones or fragments during sequence of construction securely rammed into place. Ends of riprap walls shall be keyed into the earth or embankment slopes a minimum of 24 inches from the outer face of the riprap for the full height of the riprap wall. The finished work shall present an even, tight and reasonably plane surface, varying not more than three inches from the general contour of the revetment.

Where the riprap thickness is not shown on the plans it shall be at least twelve inches measured perpendicular to the slope.

(2) **Random Riprap.** The stone, graded so the smaller stone is uniformly distributed, shall be handled or dumped on the designated

slopes to form the cross section shown on the plans or as directed. The rock shall be manipulated by hand or machine methods sufficiently to secure a regular surface and mass stability. Where the thickness of the riprap is not shown on the plans it shall be at least eighteen inches measured perpendicular to the slope. Unless otherwise directed, riprap shall extend from two feet below the toe of the slope to mean high water elevation.

When random riprap is specified for placement around pipe openings, special care shall be taken in placing and handling. Manipulation of individual rocks during placement of riprap shall be as the engineer directs. Pipe which is damaged shall be repaired or replaced at no expense to the Department.

50.13 GROUTED RIPRAP. Except as hereby provided, "Grouted Riprap" shall conform to the specifications for "Hand Laid Riprap."

(A) Material.

(1) Grout shall consist of one part of Portland cement and three parts of sand, thoroughly mixed with water to produce a mortar of a thick cream consistency. Mortar shall be used within thirty minutes after water is added and the mortar shall not be retempered.

(2) Fine Aggregate shall conform to Article M-100.01 (A).

(B) Construction Methods. The revetment shall not be less than nine inches in thickness. Care shall be taken to keep earth and sand from filling the spaces between the stones.

When required, bedding material consisting of one or more layers of graded material meeting the requirements of Article M-100.11 shall be placed on a prepared area, prior to placing the riprap.

Bedding material shall be placed on the prepared area to the full specified thickness of each layer in one operation. The methods used shall not cause segregation of particle sizes within the layer. The surface of the finished layer shall be reasonably even and free from mounds or ridges. Additional layers of filter placed shall not cause mixing of materials.

After the stone has been placed, the voids shall be filled with spalls or small stones in such manner that all stones are tightly wedged or keyed. The finished surface shall present an even, tight surface with the plane not varying more than three inches from the general contour.

Following completion of laying all stone in the revetment and immediately preceding the placing of any grout, the surface shall be wetted with water. The crevices and openings shall be filled with mortar to a minimum

depth of three inches, followed immediately by sweeping the surface with a stiff broom.

Grouting will not be permitted in freezing weather. When grouting is done in hot dry weather the work shall be protected by keeping it moist with water or a wet earth blanket for three days following its completion.

50.14 SACKED CONCRETE RIPRAP.

(A) Material. The concrete produced in an approved type mixer, shall consist of one part Portland cement and ten parts of aggregate by volume. Pit run aggregate material complying with these specifications may be used. The amount of water added at the time of mixing shall be such as to result in a mixture with a three to five inch slump when tested in accordance with Montana Test Method—M.T. 104. Sacks shall be sound, ten ounce burlap sacks or equal, approximately eighteen inches wide by thirty inches long. If reclaimed, they shall not have contained any materials injurious to concrete. The aggregate shall consist of gravel and sand meeting the following grading requirements:

Passing a screen having 3-inch square openings.....	100%
Passing a screen having 1/4-inch square openings.....	30-50%
Passing a 100-mesh sieve, not more than.....	5%

Aggregate shall be free of organic matter or other deleterious substances.

(B) Construction Methods. Trenching preparations for sacked concrete riprap shall conform to Article 50.12 (B) (1).

The sacks shall be filled two-thirds with concrete and securely tied with heavy cord. Immediately upon filling, the sacks shall be placed by hand methods and kneaded into conformance with the trench and backslope or the adjacent sacks already in position. They shall be of uniform thickness along any cross section that is perpendicular to the longitudinal axis of the sack.

The first course of sacks shall consist of a single row of "stretchers" laid in the trench with the tied ends out. The second course shall consist of a single row of "headers" laid with the tied ends toward the earth slope. Succeeding courses shall be laid as "stretchers" with the tied ends out. Sacks shall be laid in "broken joint." Joints shall be staggered to pattern and firmly kneaded into position to form a good bond. Dirt and debris shall be removed from the top of the sacks before the succeeding course is placed.

Not more than five courses of sacks shall be placked in a tier until the initial set in the first course has taken place. In placing, care in shaping the sacked concrete shall be exercised to obtain the minimum dimensions

shown in the plans and to provide a minimum of voids. Sacked concrete shall be kept moist as erection progresses and for a period of twenty-four hours following completion, by water sprinkling, moist earth covering or other satisfactory means.

50.15 METHOD OF MEASUREMENT. Hand-laid, random or sacked concrete riprap and filter blanket material will be measured complete in place to the nearest one-tenth cubic yard.

Concrete slab riprap will be covered by plan requirements and special provisions for each case.

The completed grouted riprap will be measured in place, on the face of the revetment to the nearest one-tenth square yard.

The riprap volume dimensions will be thickness as shown on the plans and the width and length as staked in the field.

50.16 BASIS OF PAYMENT.

The accepted quantities determined as provided above will be paid for at the contract unit price, which price and payment shall be full compensation for the work, including trench excavation unless otherwise specified.

When shown on the plans and stipulated in the contract, trench excavation will be measured and paid for in accordance with Article 52.02.

SUBSECTION 50.20 RUBBLE MASONRY

50.21 DESCRIPTION. "Rubble masonry" shall consist of either "dry" or "cement" walls, as specified, composed of stones or quarried rock, constructed in conformity with the plans and specifications or as directed.

50.22 MATERIAL. Stone or rock shall conform to the requirements of Article 50.12 (A) (1) with the additional requirement that no stone or rock shall be used which has a thickness of less than five inches, or a width less than twelve inches, or which is less than one-half cubic foot in volume.

Mortar for cement rubble masonry shall conform to Article 50.13 (A).

50.23 CONSTRUCTION METHODS.

(A) General. All masonry shall be laid to line in courses approximately levelled up. The bottom or foundation courses shall be composed of large selected stones and all courses shall be laid with bearing beds parallel to the natural bed of the material. The vertical joints in each course shall

break joints with those in adjoining courses at least six inches. In no case shall a vertical joint be so located as to occur directly above or below a header. Stones shall be placed so they have firm bearing and will be well bonded.

Headers shall be distributed uniformly throughout the wall, to form approximately one-fifth of the exposed faces. They shall extend through the face wall and into the backing at least twelve inches. Where a wall is less than 18 inches thick, the headers shall extend entirely through from front to back face. Where the wall is more than 18 inches thick, the headers shall either extend entirely through or overlap at least six inches.

(B) Dry Rubble Masonry. In all cases the base thickness of the wall shall be at least half the wall height. The wall height shall not exceed eight feet. The wall face shall be constructed with a batter of not less than one inch to one foot.

Dry Rubble Masonry shall be built up leaving no appreciable open spaces. Only sufficient spalls shall be used to wedge the stones into place. It shall be finished with a top course or coping carefully laid in solid beds consisting of roughly shaped stones not less than six inches thick, from one and one-half to four feet long, and wide enough to cover the top of the wall.

(C) Cement Rubble Masonry. All stones shall be thoroughly wet prior to laying and shall be fully bedded in mortar. Retempering of mortar will not be permitted. Mortar shall be produced in a mixer of approved type.

The interior of the walls shall be built up so that the stones will be bonded and no open spaces left. Horizontal joints in the face shall not exceed one inch in thickness and vertical joints shall not exceed two inches in width. No spalls shall be used in the face of a wall and the face stones shall be so well bedded that none will be needed. Walls shall be provided with weep holes wherever shown on the plans or as directed. If a stone is loosened after the mortar has set it shall be removed, the mortar cleaned off, and the stone relaid with fresh mortar.

Cement rubble masonry shall be finished with a concrete coping or top course consisting of roughly shaped stones. Copings and backwalls, unless otherwise specified, shall be of class "A" concrete as specified in Section 40. It shall not be less than eight inches thick and wide enough to cover the full width of the wall and shall be cast in place. If a stone coping is specified, the stones shall not be less than eight inches thick, from one-and-one-half to four feet long and wide enough to cover the top of the wall, set in full mortar beds as shown on the plans.

After the stone is laid, as specified, the face joints shall be thoroughly

cleaned of all mortar to a depth of one inch. The joints shall then be wetted and pointed with Portland cement mortar mixed in the proportion of one part of cement to one part of sand.

No masonry shall be laid, or pointing done, in freezing weather nor when stone contains frost, unless otherwise directed. In hot or dry weather the masonry before and after pointing shall be satisfactorily protected from the sun and kept wet for a period of at least three days before completion. Work damaged by the frost or because of improper protection from the sun shall be removed and replaced at no expense to the Department.

50.24 METHOD OF MEASUREMENT. Rubble masonry will be measured for payment to the nearest one-tenth cubic yard of the completed and accepted work, in accordance with plan dimension, unless otherwise directed.

50.25 BASIS OF PAYMENT. Rubble masonry will be paid for at the contract unit bid price, which price and payment shall be full compensation for the work.

Trench excavation, when shown on the plans and specified in the contract will be measured and paid for in accordance with the requirements of Article 52.02.

SUBSECTION 50.30 BANK PROTECTION

50.31 DESCRIPTION. Bank protection shall consist of furnishing and placing rock or coarse gravel protection to the side slopes of channels at structures or elsewhere as shown on the plans, in conformity with these specifications and as directed.

50.32 MATERIAL. The rock shall be hard, dense and durable. Either quarried rock or natural coarse gravel may be used. It may be obtained from adjacent roadway excavation. It shall be reasonably well graded from the maximum to the minimum sizes specified.

The sizes of material for the different types and thicknesses and the range of gradation shall be as follows:

Type	1	2	3	4
Nominal Thickness	24 In.	18 In.	12 In.	Coarse Gravel
Overall thickness, including bedding	30 In.	24 In.	18 In.	As prescribed on the drawings.
Largest rock permissible	1/4 C.Y.	1/8 C.Y.	1 C.F.	1/8 C.F.
Smallest rock permissible	1/10 C.F.	1/10 C.F.	1-½ In.	3/16 In.

50.33 CONSTRUCTION METHODS. The rock, in bank protection, need not be handplaced. It may be dumped and leveled by moving rocks into position in such a manner as to insure that the completed work is stable without tendency to slide with no unreasonably large voids or unfilled spaces.

The inclusion of rock spalls or gravel in an amount not in excess of that required to fill the voids in the material, as determined by the engineer, will be required. Earth, sand, or rock material less than three-sixteenths inch will not be permitted in excess of five percent.

If specified, the bank protection shall be bedded in a continuous layer of acceptable sand on natural or crushed gravel six inches thick, reasonably well-graded to a maximum of 1½ inches.

50.34 METHOD OF MEASUREMENT. Bank protection will be measured to the nearest one-tenth cubic yard of completed and accepted bank protection in place, for the type called for on the plans.

When rock material for this item is obtained from the roadway or other prescribed excavation, no deduction from the excavation yardage for the stone, so used, will be made. If excavation for bank protection is a separate item, it will be measured in conformity with Article 52.04.

50.35 BASIS OF PAYMENT. Bank protection will be paid for at the

contract unit price, per cubic yard, which price and payment shall be full compensation for furnishing and placing the bank protection complete in place. When excavation for bank protection is a separate item it shall be in accordance with the provisions of Article 52.02 and paid for in agreement with Article 52.05.

SUBSECTION 50.40 CONCRETE SLOPE PROTECTION

50.41 DESCRIPTION.

Concrete slope protection shall conform to the requirements of Standard Drawings with the following additional provisions:

Cast in place concrete shall be constructed of Class "DD" concrete conforming to Article 40.02.

50.42 PREPARATION OF SUBGRADE.

The subgrade shall be formed by trenching and shaping in conformity with the details and required elevation set forth on the plans and standard drawings as directed. The excess excavated material shall be disposed of as directed.

The subgrade shall be thoroughly compacted to insure its stability and trimmed to a reasonably smooth plane to the satisfaction of the engineer.

50.43 JOINT MORTAR.

The joints, between units, shall be filled with cement mortar conforming to Article M-150.02 (3) with the additional provisions that mortar sand shall conform to Article M-100.01 (A). The blocks shall be wet down at least one hour before placing the mortar.

Mortar shall be placed from the bottom to top and sufficient mortar shall be used and worked with suitable tools to completely fill the joints between the units. Any excess mortar shall be removed from the surface.

Joint mortar work shall not be accomplished in freezing weather. When placing is done, in hot dry weather, the work shall be protected by keeping it moist with water or approved membrane curing compound for three days following its completion. Any work damaged by frost or because of improper protection shall be removed and replaced at the contractor's expense.

The precast blocks and cast-in-place concrete shall be made with air-entrained admixture conforming to Article 40.04 (A) (2).

50.44 SAND GRAVEL CUSHION.

The material for the sand gravel cushion shall conform to Article M-100.11 with the additional provision that all material shall pass a 1½ inch sieve.

50.45 METHOD OF MEASUREMENT.

Concrete slope protection will be measured by the area in square yards of exposed surface, to the nearest one-tenth square yard, complete and accepted in place. The measurement shall include precast blocks, concrete headers, cut-off walls and cast-in-place concrete. All measurements will be made parallel to the surface of the concrete slope protection.

Sand-gravel cushion will be paid for at the contract unit price per in the completed and accepted work compacted in place.

50.46 BASIS OF PAYMENT.

Concrete slope protection will be paid for at the contract unit price per square yard, which price and payment shall be full compensation for all excavation, preparation of subgrade, trimming of slope, disposal of surplus material and furnishing and placing all materials and all labor and equipment necessary to complete the work, including concrete headers, and cut-off walls but not including sand-gravel cushion.

Sand-gravel cushion will be paid for at the contract unit price per cubic yard, which price and payment shall be full compensation for furnishing and placing the material as specified. While sand-gravel cushion material may not be specified on the plans, such an item may be included in the contract as an arbitrary quantity for the purpose of providing a contract unit price for any quantity of bedding material that may be required. The quantity shown in the contract, under such a condition, will not be guaranteed to be required or used and the Department reserves the right to increase, decrease or omit any or all of the item and no additional compensation will be allowed by reason thereof.

SECTION 51

RETAINING WALL

51.01 DESCRIPTION. Work under this section shall consist of the furnishing of the necessary materials and the construction of concrete or metal retaining walls conforming to the lines, grades and dimensions given, and in conformance with plans, specifications and special provisions.

51.02 MATERIALS.

(A) Concrete Retaining Walls. Concrete and reinforcing steel shall conform to Sections 40 and M-290 and the plans unless otherwise specified.

(B) Metal Bin-Type Retaining Walls. Metal bin-type retaining walls shall meet the requirements of the plans and the special provisions. The necessary bolts and appurtenances shall be furnished for complete assembly of the units into a continuous closed face wall of connected bins. The units in the structure shall conform to the dimensions shown on the plans, and standard drawings.

All metal sheets and plates shall be the gauge shown on the plans. Sheet metal for bin-type retaining walls shall be galvanized. The base metal, rivets, bolts, nuts, other hardware and galvanizing shall meet the requirements of the provisions of AASHTO M-36; the base metal shall bear at least 0.2% copper. Hardware not covered above shall be galvanized in accordance with ASTM A-153. All units shall be so fabricated that units of the same nominal size shall be fully interchangeable. No drilling, punching or drifting to correct defects in manufacture shall be permitted. Units having holes improperly punched shall be replaced at no cost to the State. When bituminous treated walls are specified, treatment and handling shall be in conformity with Article M-170.03.

51.03 CONSTRUCTION METHODS.

(A) Foundations. All foundations shall be prepared as specified by Article 52.03 and they shall be inspected and approved prior to placement of the structure. Concrete base slabs, when required, shall be placed and allowed to set before the superstructure is constructed.

(B) Concrete Retaining Walls. Dimensions, layout and details as

shown on the plans shall be adhered to in all respects. Before concrete is placed in the walls, the footings shall be thoroughly cleaned of all shavings, sticks, sawdust, or other extraneous material. The surface shall be carefully chipped and roughened in the method of bonding constructions joints as specified by Section 41.04(G). Necessary construction joints shall be vertical. Drains through all walls are to be placed as shown on plans or as directed by the engineer in the field. Dimensions and details shown on the plans and standard drawings shall be followed as required.

(C) Bin-Type Retaining Walls. The units and parts making up the walls shall be assembled in agreement with the plans and the completed product shall present a neat, uniform, workmanlike appearance. The ends of all stringers and spacers shall be securely bolted to corner columns by means of connecting channels. In the construction of a wall on a curve the proper curvature for the face shall be obtained by the use of shorter stringers in the front or rear panels of retaining walls as designated on plans or by the engineer. The wall height and depth may be varied, but not to exceed the maximum dimension shown for the design selected. Two or more designs of retaining walls may be incorporated in the same wall by the use of standard split columns to make the connection on the step-back. The units shall be erected as shown on the plans. Members shall be handled carefully and those which are damaged shall be removed and new members substituted at the contractor's expense. Members with damaged or broken spelter shall be rejected. When the walls have been bituminous treated, broken or damaged bituminous cover shall be painted with acceptable bitumen.

(D) Backfill.

(1) Concrete Structures. Backfill shall be composed of material approved by the engineer and shall be placed as specified by Article 11.04(B).

(2) Metal Bin-type Retaining Walls. Backfill outside the bins shall be made with material as excavated and used for construction of the roadway or as approved. It shall be placed as specified above in (1). No separate and special payment shall be made for this backfill. Backfill inside and outside bins shall progress simultaneously. The inside of the bins shall be backfilled with material conforming to the provisions of Article 54.05.

Backfill shall be placed in layers not to exceed eight inches in thick-

ness. It shall be thoroughly compacted, using hand controlled mechanical tampers.

51.04 METHOD OF MEASUREMENT.

- (A) Concrete will be measured in accordance with Section 41.
- (B) Reinforcing steel will be measured in accordance with Section 47.
- (C) Excavation will be measured in accordance with Article 52.02 and 52.04.
- (D) Metal bin-type retaining walls will be measured by the nominal square foot of facial area of wall.
- (E) Unless specified otherwise, backfill material will not be paid for directly but will be considered incidental to and absorbed in payment for the other items of the contract.

51.05 BASIS OF PAYMENT.

- (A) Concrete will be paid for in accordance with Section 41. The contract unit price and payment shall be full compensation for the concrete and for all necessary materials and incidentals necessary to complete the item, but will not constitute payment for reinforcing steel. Reinforcing steel will be paid for separately.
- (B) Reinforcing steel will be paid for in accordance with Section 47.
- (C) Excavation shall be paid for in accordance with Article 52.05.
- (D) Metal bin-type retaining walls will be paid for by the nominal square foot of facial area as bid, which price and payment shall be full compensation for the work. This item will be bid as "metal retaining wall" or as "bituminized metal retaining wall" when treated in accordance with Article M-170.03.
- (E) Unless specified otherwise, backfill material will not be measured or paid for directly but will be considered incidental to and absorbed in payment for the other items of the contract.

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SECTION 52

EXCAVATION FOR CULVERTS AND MINOR STRUCTURES

52.01 DESCRIPTION. Excavation for culverts and minor structures shall consist of all excavation for foundations for culverts, retaining walls, trenches, for sewers, water pipe, riprap, masonry and other minor structures and for excavation necessary for the removal of culverts from existing roadbeds and from other locations and shall include the disposal of all material obtained from such excavation and backfilling to the level of the original ground. Unless otherwise specified by the plans or special provisions, it shall also include all necessary bailing, drainage, sheeting and the construction of shoring and cribs as necessary.

The contract will specify the particular type or types of excavation involved in the project. Ditches at inlets and outlets of culverts and any other ditches indicated in the plans shall be constructed under excavation items conforming to Article 11.02.

52.02 CLASSIFICATION. All material excavated will be paid for as culvert excavation unless otherwise provided in the special provisions.

The excavation lines and bases of culverts or structures shown on the plans shall be considered as approximate only, and they may be placed at any elevation, or of any dimensions necessary to give a satisfactory foundation, and no additional compensation will be allowed for any such change except as provided under basis of payment.

Boulders, logs, or any unforeseen obstacles encountered in excavating shall be removed and no additional compensation will be allowed because of difficulties found in removing such obstructions.

Culvert or structure excavation shall include only that excavation which is removed from below the lines of the planned or staked template section, whether it be roadway, channel change or otherwise.

When culverts are to be placed in embankment sections, the natural ground line as cross-sectioned will be the uppermost level of computation unless otherwise indicated on the plans or specified in the special provisions or as directed by the engineer.

In cut sections, culvert excavation will be measured below the limits of roadway excavation. However, when it is required by the engineer that a

culvert be placed in a cut section prior to excavation for the roadway, culvert excavation will be allowed to the original ground line.

52.03 CONSTRUCTION METHODS.

(A) General. Material removed below the designed elevation shall be replaced with approved material. Suitable surplus excavated material shall be used in the construction of roadbed embankments.

Sides of trenches, including embankments, shall be shored or otherwise supported when the trench is more than five feet in depth and eight feet or more in length. However, if the excavation is in solid rock, shale or cemented sand and gravel, unshored vertical walls will be permitted.

In lieu of shoring, the sides of the trench may be sloped from a hinge point, one foot outside the neat lines of the pipe on the trench floor. Such excavation limits will be staked on a 1:1 ratio to an intersection with the natural ground for volume determination. When special foundation stabilization is required the hinge point shall shift to accommodate the additional width for the trench. The walls of the bedding trench shall be vertical and sloping shall be from the top of the bedding trench wall and not from the bedding floor. Trench widths for multiple installations shall be as indicated in the standard drawings or as shown on the plans.

If, during excavation, it is determined by the contractor and the engineer that the sides of the trench are unstable, the contractor shall lay back the sides of the trench to a stable slope in order to meet proper safety requirements. The additional material so removed will be paid for as regular culvert excavation.

Backfilling of excavated areas shall be done in accordance with Article 54.05.

No backfill shall be placed against newly constructed masonry or concrete structures for a period of 14 days unless authorized by the engineer. All sheeting and bracing used in structure excavation shall be removed after completion of work, unless otherwise indicated on the plans or directed by the engineer.

(B) Foundation Preparation — General. The foundation of each pipe culvert or minor structure shall conform to the lines and grades established by the engineer. An allowance will be made for the required camber for pipe culverts.

The density of foundations, for culverts or minor structures, shall be as specified in Article 11.05, unless otherwise directed.

Unstable foundation material shall be removed as directed below the

designed elevation. All unsuitable material shall be wasted. The unstable material shall be replaced, as shown in the standard drawing with bedding material meeting the requirements of Article M-100.11.

Hardpan or other unyielding material shall be removed, as directed, below the designed elevation for a depth of approximately 12 inches minimum. The material to replace this extra depth excavation shall be a granular backfill or a similar free-draining material obtained from roadway excavation, if available.

When unsuitable material, such as peat, muck and the like, is encountered at or below the invert elevations, sub-surface exploration and analysis will be made. Corrective measures shall be accomplished as directed.

Bedding material shall be omitted when directed.

Bedding for culverts shall meet the requirements of the Standard Drawings, with the exception of culverts 12 inches in diameter and smaller, unless specified otherwise.

No pipe shall be laid until the foundation has been approved. Any pipe laid without prior approval shall be removed and relaid properly at no additional cost to the State.

(C) Foundation Preparation — Reinforced Concrete Pipe. The foundation for reinforced concrete pipe shall meet the foregoing requirements and in addition may be required to be either Class A, Class B, or Class C, as shown on the standard drawing, if so stated in the special provisions or plans. Class C bedding will be used unless specified otherwise.

52.04 METHOD OF MEASUREMENT. For the trenches not shored or cribbed and five feet or more in depth, the quantity of excavation to be paid for will be the volume bounded by and computed within the lines as staked in conformance with Article 52.03. For trenches less than five feet in depth, measurement will only include excavation bounded by the bottom planes as established and twelve inches outside the neat lines of vertical planes, including ends of all culverts not entering structures.

Trenching performed for shoring, cribbing, or the use of sliding protective devices, will only include excavation bounded by the bottom planes as established and 18 inches outside the neat lines of vertical planes.

When pipes, culverts or trenches penetrate manholes, boxes, headwalls or minor structures of any type, excavation will only be measured to the outside neat wall dimension of the minor structure so entered.

Culvert excavation, unless otherwise specified, will be computed to the nearest one tenth cubic yard in its' original position for the material acceptably excavated.

Excavation for riprap, rubble masonry, retaining walls, cut-off walls, headwalls, manholes, drop inlets, catch basins, headgates, division boxes and similar minor structures will not be measured. Payment shall be absorbed in the price paid for such items unless specified otherwise.

Excavation for flared end terminal sections or special end sections will be based on regular barrel dimensions extended through these sections. No additional excavation will be allowed for special or flared end terminal sections.

Bedding material will be measured in conformity with Article 54.06.

52.05 BASIS OF PAYMENT. The accepted quantities of excavation will be paid for at the contract unit price per cubic yard. The unit price per cubic yard shall include the placing and compacting of all backfill when the materials used are obtained from excavation, any clearing and grubbing required and not paid for under some other item, formation of any embankments made with material from structure excavation, and disposal of all surplus or unsuitable excavation, unless otherwise specified.

The unit price per cubic yard shall also include all costs incurred, or associated with, providing exit means for trenching operations.

When specified as an item, payment for shoring and cribs, will be made at the contract Lump Sum price, which call be full compensation for the construction and subsequent removal of all shoring and cribs; and for all materials, labor, equipment, tools and incidentals necessary to complete the work.

When not specified as an item, shoring and cribs will be considered to be in the contract unit price for Culvert Excavation.

SECTION 54

INSTALLATION OF PIPE CULVERTS

54.01 DESCRIPTION. This specification describes the general requirements for all types, classes and designs of standard manufacture precast or prefabricated and structural plate culvert pipe including the extension of existing culverts except as may be modified or supplemented in the particular specifications for the respective pipe culverts specified. The exact types, classes, shapes, dimensions and locations for the culverts will be stipulated in the contract shown on the plans or designated.

The locations and lengths of individual pipe culverts shown on the plans are approximate only and are subject to revision, as may be required, during the course of the work.

54.02 MATERIALS AND MANUFACTURE. All culvert pipe used in the completed and accepted work shall meet the requirements for materials and manufacture as set forth in the specifications for the particular type, class and design specified. Materials shall have been tested according to the requirements and accepted for use, at the manufacturing source. Pipe showing manufacturing or material defects which prevent proper installation or shows abuse or damage from improper handling in transit or on the job shall not be installed.

54.03 CONSTRUCTION METHODS.

(A) Except as may be modified or supplemented by the contract or plans for the respective types, classes or designs, all pipe shall be installed in accordance with the requirements of this specification.

The contractor shall not order any pipe until a correction list of sizes and lengths have been furnished him by the engineer.

(B) In the absence of specific requirements and plans for any particular installation of multiple lines of pipe, the culverts when fitted with aprons or flared end sections, shall be laid in such position that the ends of the aprons or flared end sections will form contact.

(C) The foundation shall be prepared in accordance with Article 52.03.

(D) Bedding material shall be placed in accordance with the provision of Standard Drawings No's. 40 and 41.

54.04 INSTALLATION.

(A) Precast Rigid Pipe. Reinforced concrete, concrete, tile, and the like, unless otherwise directed, shall be laid on the foundation in standard section lengths, starting at the outlet end of the culvert, with the groove or bell ends upgrade, with all bell ends suitably recessed into the foundation.

The pipe ends shall be forced together to form a positive tight fitting joint in a manner that will apply uniform pressure along the entire circumferential ends of the sections. The use of pry bars, jacks or equipment which will damage the pipe will not be permitted.

The joints of all round culverts used for irrigation, sewage, syphons or other purposes subjecting the installation to a continuous flow, or where infiltration might occur, (denoted on plan summary sheets under the heading "RCP IRRIGATION") shall be sealed with rubber type gaskets conforming to and installed in accordance with ASTM C-443, or AASHTO M-198. Rubber type gaskets shall not be used in concrete arch culverts or concrete stockpasses. For these installations other types of compounds may be used for joint sealer subject to DOH Laboratory approval.

The joints of culverts used in normally dry installations may be sealed with the above gasket type materials. If cement grout is used, it shall be made up of one part Portland cement and two parts sand conforming to sand requirements of Article M-100.01(A). The joints shall be thoroughly prewet and the grout placed onto the joint surfaces immediately prior to being forced together. If the joint is not completely filled after forcing together, additional grout shall be added to fill the joint level with the surface of the circumference. Cement grout, in normally dry installations, shall be applied only to the upper half of the outside circumference and the lower half of the inside circumference with a two inch overlap on each side.

When using cement grout the inside of the joints shall be wiped smooth of excess grout so as not to impede flow.

All concrete pipe joints shall be treated by one or more of the methods covered above — no installations shall be permitted without gasket or grout — except when open joints are designated.

In addition to the ordinary installation and that called for in Paragraph Three as "RCP IRRIGATION" the plans and contract may call for syphons. When the head on a syphon pipe is over 15 feet, the installation will be specifically designed and installed in accordance with the plans or respective standard drawings. The word "syphon" will be used in the item description in the contract.

All angles, turns and branch connections shall be made with standard manufactured sections or shall conform to standard drawings. All dead

ends of sewers and branches shall be constructed with tightly closed ends or shall be closed with stoppers, of strength equal to the pipe securely cemented in place.

Trenches in which sewers are to be constructed shall be kept as nearly dry as practicable at the time the pipe is placed and during the period the joint filler material is setting.

(B) Prefabricated Flexible Pipe. Corrugated Metal Syphons, and the like. The pipe shall be laid on the foundation with separate sections approximately one inch apart to cause mesh or corrugations with outside laps of circumferential joints pointing upgrade and with the longitudinal joints on the sides. The sections shall be connected with specified types of coupling bands firmly bolted. The coupling bands shall be tapped with a mallet or other suitable tool as they are tightened.

Pipe shall be so handled in laying as to prevent bruising, scaling or breaking of the spelter coating or other type of cover. In no case shall pipe be dropped or dragged in unloading.

Culverts, used for irrigation or under other conditions, where there is a continuous flow of water for extended periods will be designated on the plans as "CSP or CAP Irrigation," and as separate items from drainage, syphon or combination irrigation and drain pipes.

Culverts, used for syphons, under head or pressure, will be designated on the plans as "CSP or CAP Syphon," and as separate items for drainage, irrigation or combination irrigation and drain pipes.

Both CSP or CAP Irrigation and CSP or CAP Syphon pipes shall be close-riveted and soldered, welded and soldered, or fabricated from Lock Seam or Welded Seam Helically Corrugated Steel Pipe. Fabrication shall be in conformance with AASHTO M-36.

Field Joints shall be made in accordance with the following to form watertight connections:

Annular Corrugated Steel Pipe. A corrugated steel coupling band of the "Rod and Lug" type shall be the basic connection. The corrugated bands shall be not less than 12 inches wide for diameters 8 to 30 inches inclusive and not less than 24 inches wide for diameters greater than 30 inches. Four rods and lugs are required for 12 inch wide bands and six rods and lugs for the 24 inch wide bands.

Helical Corrugated Steel Pipe. The basic connection shall be field jointed with coupling bands having projections. The bands shall not be less than 10 1/2 inches wide for diameter 8 to 30 inches inclusive and not less than 24 inches wide for diameters greater than 30 inches.

Thickness of coupling bands, lap on pipes to be joined and material

specification shall be in conformance with AASHTO M-36. The portion of the pipe that will be covered by connecting bands shall be welded or riveted with flush type rivet heads, unless formed with helical corrugations. There shall be furnished with each coupling band sufficient gasketing material, fibrous asphalt compound or O-Ring gaskets to insure a watertight bond between the pipe and the coupling band. The band shall be securely tightened around the joint.

If the manufacturer or the contractor has an alternate method, using different materials than above, and he can assure the laboratory and the engineer of adequate strength and a watertight connection, then same may be permitted. If neither of the above is successful, the contractor must correct the installation and secure a watertight connection.

(C) Structural Plate Types. Except as herein modified or supplemented, field erection shall be performed in accordance with the specifications furnished by the manufacturer or as stipulated in the contract and shown on the plans. Erection shall not be started or proceed until the engineer and contractor have the manufacturer's specifications and instructions at the work site. No backfill shall be placed above the base until all plates in a ring have been completed and all bolts in the structure have been tightened in accordance with specifications.

Within the area three feet from neat lines of the pipe culvert, compaction shall be accomplished with light weight compaction equipment.

All bolts used in the erection shall be tightened to a torque of 200 foot pounds with a tolerance of plus or minus 50 foot pounds. During the course of installation, the engineer will make sufficient tests of the tightened bolts to insure strict compliance with this requirement.

Long span (super span) structures shall be governed by the special provisions.

(D) Pipe Underdrains. All pipe installed for this purpose shall be laid in a trench excavated to the lines and grades shown on the plans or as established. The bottom of the trench shall be shaped to accurately fit the pipe and shall be of sufficient dimension to permit placing of approved type aggregate backfill material. Unless otherwise provided, the pipe shall be laid in such manner that it is encased in a minimum of twelve inches of filter material, conforming to specified standard drawings covering under-drain backfill.

Perforated pipe shall be laid with the perforations down, unless otherwise directed. The earth backfill material shall be placed adjacent to the

filter material and compacted in the manner specified for foundation preparation under Part (C), Article 52.03.

(E) Rigid Type Underdrains. All underdrain pipe of this type shall be laid in the same manner as flexible type underdrains and according to the specifications for installation of surface drain pipe, except that the joints shall be left open with the spigot or tongue end kept a distance of one-half inch from closure. If directed all joints shall be wrapped with a six inch strip of ten ounce burlap, one-and-one-half times around the joint, the lap providing double thickness on top of the joints.

54.05 BACKFILLING.

(A) All Types. All backfilling shall meet the following requirements except when other methods are specified for certain types of installations.

Backfill material shall not contain sticks, sod, frozen soil or other unacceptable matter. Backfill material placed within one foot of the pipe shall be substantially free of stones, rocks, chunks of broken concrete and similar material larger than three inches.

Backfill shall be firmly tamped under the haunches of the pipe.

Backfill material shall be placed in layers of six inch loose thickness or less. All backfill material placed within excavation limits shall be compacted. Compaction of backfill material placed above excavation limits or the ground line shall extend a distance, from each side of the culvert, equal to twice the culvert diameter or twelve feet, whichever is less.

Backfilling and compaction shall progress at approximately the same elevation on each side of the culvert up to an elevation of at least one foot above the top of the culvert. Compaction shall be in accordance with Article 11.05.

Equipment and methods used in backfilling and compacting shall not distort, misalign or otherwise damage pipes. Distortion, misalignment or other damages to pipes caused by the equipment or methods shall be repaired by removing and installation or other methods satisfactory to the engineer.

Heavy equipment shall not pass over any culvert until material has been placed and compacted over the culvert to a depth of at least four feet or one-half the culvert diameter, whichever is more. The contractor shall correct all damage to any culvert or culvert installation caused by hauling equipment or his method of operation, at no cost to the State. The surfacing contractor, when the roadway is constructed in separate contracts for grading and surfacing, shall remove humps over each

culvert, dispose of the material as directed and construct the area to the proper grade, before placing the surfacing materials.

(B) Imperfect Trench Method. When reinforced concrete culverts are installed beneath an embankment, and the imperfect trench method of backfill is specified, backfill shall be performed according to the following described method.

A trench shall be excavated directly over the pipe for its full length. Its width and depth shall be equal to the outside diameter of the pipe. It shall be neatly excavated with vertical sides. Machinery that will not accomplish this section will be prohibited and hand excavation called for if necessary. One foot of compacted material shall remain over the pipe.

The lower one-third of the excavated ditch section shall then be filled with loose straw and then completely filled with loose highly compressible material. The embankment may then be constructed in the normal manner.

Excavation of the fill in the prism above the pipe will not be measured or paid for directly but shall be considered as a subsidiary obligation and necessary and incidental to installation of the culvert and included in the contract unit price for the pipe.

(C) Rock Embankment. In case the installation is to be under an embankment principally composed of blasted or fractured rock of varying dimension, the exposed surface of the pipe, except as otherwise specified, above the level of the graded bedding material shall be encased with selected earth material for one-half the nominal diameter of the pipe excepting in no case shall it be less than three feet. Where no graded bedding material is specified, the selected earth material shall extend around the full exposed pipe surface.

The selected earth material, for encasement, shall be free of any material detrimental to the culvert installation. It shall be placed and compacted in conformity with paragraph (A) preceding.

Selected earth material, for culvert encasement, shall be measured as Unclassified Excavation or Unclassified Borrow, as the case may be. The furnishing of the material and placement thereof shall be paid for in accordance to the respective contract unit prices provided for completing these items in the contract.

54.06 METHOD OF MEASUREMENT. Pipe used in the completed and accepted work will be measured by the linear foot. Pipe culvert, of all types, will be measured from end to end of the structure along the bottom

or flow line. Measurements will include flared ends when installed, beveled, skewed and similar shapes or special designs.

Pipe installed in excess of the length ordered by the engineer will not be measured for payment. Bedding material shall be measured by the cubic yard as used in the completed and accepted work, compacted and complete in place.

54.07 BASIS OF PAYMENT. Pipe culverts and stockpasses will be paid for at the contract unit price, which price and payment, unless otherwise specified, shall be full compensation for furnishing and installing the pipe, hauling, preparation of pipe foundation including bedding blanket, placing and compacting backfill material, and for all materials, mortars, coupling connections, bolts, fittings, labor, tools, equipment and all incidentals necessary to complete the pipe installation, with the exception of the necessary excavation and compacted in place bedding material which will be paid for as a separate item.

Should it be determined in construction that the length of any culvert or installation of pipe shown on the plans is inadequate, then the contractor shall provide and place the additional length required at the contract unit prices for the appropriate type, and dimension, including the furnishing and placing of additional coupling bands.

Bedding material shall be paid for at the contract unit price and payment shall be full compensation for the work. While bedding material may not be specified by the plans, such an item may be included in the contract as an arbitrary quantity for the purpose of providing a unit price for the quantity of bedding material that may be required. The quantity shown in the contract, under such a condition, shall not be guaranteed to be required or used and the Department reserves the right to increase, decrease or omit any or all of such items and no additional compensation will be allowed by reason thereof.

NOTES

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SECTION 55

REMOVE AND RELAY PIPE CULVERT

55.10 DESCRIPTION. "Remove and Relay Pipe Culverts" shall consist of the removal of any type, class and dimension of pipe culvert from beneath the existing roadbed and from other locations shown on the plans, or as directed. The work shall also include the cleaning, preserving and relaying of this pipe at locations as directed or shown on the plans or storing of the pipe on the project, as directed.

55.20 CONSTRUCTION METHODS. Excavation necessary for the removal of pipe culverts may be made by any method that does not involve injury to the pipe. Any pipe which, in the course of removal or handling, becomes bent, torn, crushed or otherwise damaged beyond reuse shall be replaced by the contractor with an equal length of pipe of the same diameter, of quality and condition equivalent to the condition of the damaged pipe prior to its removal. An old pipe culvert being relaid shall be cleaned, as thoroughly as practicable, of dirt, rubbish and other materials prior to being relaid.

Backfill of the excavation occasioned by removal of pipe culvert within the template section of the new roadway shall meet requirements of Article 11.04.

Relaying of pipe shall meet pertinent requirements of Section 54.

55.30 METHOD OF MEASUREMENT. When stipulated in the contract and shown on the plans removal of pipe culverts will be measured by the linear foot of the completed and accepted work. When shown on the plans, but not stipulated in the contract, removal of pipe culverts will be considered subsidiary to the culvert excavation required for their removal.

Relay of pipe culverts will be measured by the linear foot of the completed and accepted work in accordance with the applicable requirements of Section 54.

Excavation necessary to remove pipe culverts, to be relaid or stored, will be measured from the profile of the existing surface to the bottom plane of the culvert and according to the provisions of Section 52.

55.31 BASIS OF PAYMENT. Relay of pipe culverts will be paid for at the contract unit price, which price and payment shall be full compensation for removal, cleaning, preserving, cutting, handling, hauling, laying and, if required, storing, of the various types, sizes, classes and dimensions of pipe removed, or pipe furnished in lieu of that removed; for the furnishing of any coupling bands, mortar and for all incidentals necessary to complete the work.

Excavation required to remove pipe culverts or to relay pipe culverts will be paid for at the contract unit price for "Culvert Excavation," in agreement with Section 52.

The excavation work necessary for the removal of culverts of the various types, irrespective of size, shall be measured and paid for as culvert excavation in agreement with the provisions of Section 52. All other work involved in removing the old culverts, including the removal of headwalls, shall not be paid for directly, but shall be considered as subsidiary work pertaining to the roadway and drainage excavation items.

SECTION 56

CORRUGATED STEEL PIPE CULVERTS

56.01 DESCRIPTION. Corrugated Steel Pipe, meeting these specifications shall be furnished and installed as specified by the plans, specifications or as directed. All pipe covered by this section is round or elliptical.

56.02 MATERIALS AND MANUFACTURE. Corrugated steel pipe shall meet the requirements of Section M-170, except as those requirements may be supplemented or modified herein or by special provisions.

Pipes furnished in elliptical form shall be formed and fabricated, at the plant or factory, five percent out of round to form an elliptical section. Culverts to be elongated shall be indicated on the plans.

One end of the steel pipe "T" sections for connection to median inlets shall be capped, if required. The cap shall be constructed of metal equivalent to the pipe and fastened to the "T" section in a manner as necessary to be water tight and develop a strength equivalent to the wall strength of the pipe.

When galvanized steel pipe culverts are required to be asbesto-bonded, bituminous coated or provided with a paved invert, work and materials shall meet the requirements of Section M-170.03.

56.03 CONSTRUCTION METHODS. Construction methods shall conform to Article 54.03.

56.04 METHOD OF MEASUREMENT. Measurement of Corrugated Steel Pipe Culvert will be by the linear foot and will include riser pipe lengths and riser tee sections and as further provided in Article 54.06.

56.05 BASIS OF PAYMENT. Corrugated Steel Pipe Culvert, including riser pipes and riser tee sections, will be paid for at the contract unit price, per linear foot, and meeting the requirements of Article 54.07.

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SECTION 57

CORRUGATED STEEL PIPE

ARCH CULVERTS

57.01 DESCRIPTION. "Corrugated Steel Pipe Arch Culverts," meeting the requirements of these specifications shall be furnished and installed as specified by the plans, specifications or as directed.

57.02 MATERIALS AND MANUFACTURE. Corrugated steel pipe-arches, instead of being circular, shall be of a multi-centered form, with arch shaped top and slightly outward curved integral bottom. It shall have a vertical diameter or rise which is approximately sixty percent of the horizontal diameter or span. Materials shall meet the requirements of Section M-170.

Reference shall be made to plans and standard drawings concerning dimensional data, gauge of metal, and other necessary information. Standard manufacturing practice concerning sheet sizes, lap, width of bands and weights per foot shall be followed unless specified otherwise. The minimum radius of any part of the pipe-arch section shall be three inches and, shall be sufficiently great to prevent damage to the spelter coating. The lapping longitudinal seams shall be factory riveted and shall be staggered to alternate on each side of the center of the top of the arch by approximately fifteen percent of the periphery.

When galvanized steel pipe-arch culverts are required to be asbestos-bonded, bituminous coated or provided with a paved invert, such work and materials shall meet the requirements of Article M-170.03.

57.03 CONSTRUCTION METHODS. Construction methods shall meet, in general, the requirements of Article 54.03.

Strutting of pipe arches will not be required, unless specified otherwise. Field joints shall be made from band couplers shaped to fit the formed pipe.

57.04 METHODS OF MEASUREMENT. Methods of measurement shall be as provided in Article 54.06.

57.05 BASIS OF PAYMENT. Payment shall be made in accordance with Article 54.07. The contract will stipulate only the span dimension, to the nearest inch, of pipe-arch culverts in accordance with standard drawings for such culverts. The plans will carry both span and rise dimensions.

NOTES

SECTION 59

STEEL STRUCTURAL PLATE PIPE, STRUCTURAL PLATE PIPE ARCH CULVERT AND STOCKPASSES

59.01. DESCRIPTION. Steel Structural Plate Pipe, Structural Plate Pipe Arch Culverts and Structural Plate Stockpasses shall consist of furnishing and installations of such pipes, in conformity with the plans and specifications and the requirements of Section 54, except as may be herein provided or as directed.

59.02 MATERIAL AND MANUFACTURE.

(A) General. Steel structural plate pipe culverts, structural plate pipe arch culverts and structural plate pipe stockpasses shall consist of curved sections of galvanized corrugated steel plate bolted together to form required shapes. The sizes and shapes of the plates shall be such that the finished structures will have the dimensions designated herein or on the plans. Materials for pipe culverts, pipe arch culverts and stockpasses shall meet the pertinent requirements of AASHTO M-167.

Where steel structural plate pipe, structural plate pipe arch culverts or stockpasses are already in place and called for on the plans to be lengthened, the new pipe extensions shall conform as nearly as practicable to the sectional shapes of the existing pipe. Where the existing pipe has beveled ends, the beveled ends shall be removed, the new sections of culvert installed, and the beveled ends added thereto.

Beveling shall conform to the standard drawings. The slope shall be as shown by the plans.

(B) Elliptical Steel Structural Plate Pipe Culverts. Elliptical culverts shall be factory-formed with the vertical diameter elongated five percent from a true circle and the horizontal diameter decreased a corresponding amount to retain equal periphery. Installation shall be with the major axis vertical.

Culverts to be elongated shall be shown on the plans.

(C) Steel Structural Plate Pipe-Arch Culverts. Unless otherwise called for on the plans, end plates shall be beveled, as shown on the plans, above the top of corner plate. See standard drawings. A tolerance of four

percent will be allowed on span and rise of pipe arches, providing the cross-sectional area is not substantially affected.

(D) Steel Structural Plate Stockpasses. Stockpasses shall be formed by plates forming a cross-section composed of five circular arcs and flat-bottom tangent at their junctions and symmetrical about the vertical axis. A tolerance of four percent will be allowed for span and rise of stockpasses.

The periphery shall be formed by not less than six plates not more than eight plates. Span and rise of stockpasses shall be either design "A", or design "B", as indicated on the plans or standard drawing.

59.03 HANDLING AND INSPECTION. The field inspection shall be made by the engineer, who shall be furnished by the seller with an itemized statement of the sizes and lengths of the plates in each shipment. This inspection shall include an examination of the culvert materials for deficiencies in the lengths of sheets used and any evidence of poor workmanship. The inspection may include taking of samples for chemical analysis and determination of weight of spelter coating. The plates making up the shipment shall fully meet the requirements of these specifications, and if twenty-five percent of the plates in any shipment fails to meet these requirements, the entire shipment may be rejected.

Plates shall be transported, unloaded and handled in such a manner that there will be no damage to the plates. Damage resulting from improper methods of transportation or handling shall be sufficient cause for rejection of the pipe.

59.04 CONSTRUCTION METHODS. Construction methods shall meet the requirements of Article 54.03.

59.05 METHOD OF MEASUREMENT. Methods of measurement shall be as provided in Article 54.06.

59.06 BASIS OF PAYMENT. Payment shall be made in accordance with Article 54.07.

"Steel Structural Plate Pipe Culverts" will be abbreviated to "SSPP Culverts" in bid proposals.

SECTION 62

REINFORCED CONCRETE PIPE CULVERTS

62.01 DESCRIPTION. "Reinforced Concrete Pipe" meeting these specifications and the plans shall be furnished and installed as specified or as directed. This includes pipe used for sewer and underdrain purposes and reinforced concrete pressure pipe to be used for construction of irrigation systems under hydrostatic heads, generally not exceeding 100 feet.

62.02 MATERIALS AND MANUFACTURE. Reinforced concrete pipe shall meet the requirements of Section M-160, except as those requirements are herein supplemented or modified.

Concrete pressure pipe shall meet the requirements of Article M-160.12 and applicable standard drawings.

The class of pipe culvert to be used will be shown on the plans and specified in the contract. When stipulated in the contract or shown on the plans, flared end terminal sections shall be used. These sections may, at the option of the contractor, be precast standard sections or they may be cast in place meeting the requirements of the design shown on the plans or current standard drawings.

One end of the concrete pipe "T" sections for connection to median inlets shall be capped, if required. The cap shall be constructed of reinforced concrete and fastened to the "T" section in such a manner as necessary to be water tight and to develop a strength equivalent to the wall strength of the concrete pipe. The riser part of the "T" section shall meet the requirements of class III pipe, AASHTO M-170 and Article M-160.11.

62.03 CONSTRUCTION METHODS. Construction methods shall meet the applicable requirements of Section 52 and 54 and of the plans and special provisions. The type of bedding for the culverts shall be designated by the plans or special provisions and will not be denoted in item number or description.

When pipes are to be installed under railroads or high fills, additional reinforcement or wall thickness shall be provided as set forth in the plans.

62.04 METHOD OF MEASUREMENT. Method of Measurement will be |

in accordance with the requirements of Article 54.06. Riser tee sections will be included in the horizontal linear dimension of the culvert. Riser pipes will be measured by the linear foot, commencing with their mating at the tee joint and continuing to their upper most elevation.

62.05 BASIS OF PAYMENT. Payment will be made in accordance with the provisions of Article 54.07. Riser pipes will be paid for at the contract unit price per linear foot for the actual size and class of pipe installed.

SECTION 63

REINFORCED CONCRETE

ARCHES AND UNDERPASSES

63.01 DESCRIPTION. The materials and work covered by this section shall concern the furnishing and installation of reinforced concrete arch culverts, and other similar prefabricated structures meeting the requirements of the specifications and plans, or as may be directed.

63.02 MATERIALS AND MANUFACTURE.

Reinforced concrete pipe arch culverts shall meet the requirements of Section M-160.11(E).

Flared end terminal sections for reinforced concrete pipe arch culverts shall meet the requirements of standard drawings.

63.03 CONSTRUCTION METHODS. Construction methods shall meet the applicable requirements of Section 52 and 54.

63.04 METHOD OF MEASUREMENT. Methods of measurement will be as provided in Article 54.06.

63.05 BASIS OF PAYMENT. Payment will be made accordance with the applicable provisions of Article 54.07.

The contract will stipulate only the span dimension, to the nearest inch, of pipe-arch culverts in accordance with standard drawings for such culverts. The plans will carry both span and rise dimensions.

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SECTION 65

CORRUGATED ALUMINUM PIPE AND PIPE ARCH CULVERTS

65.01 DESCRIPTION. This work shall consist of furnishing and installing new corrugated aluminum culvert pipe and pipe arches at the locations shown in the plans, and meeting the requirements of these specifications or as may be directed.

65.02 MATERIALS AND MANUFACTURE. Corrugated aluminum pipe culverts shall meet the requirements of Article M-170.05 except as those requirements may be supplemented or modified herein or by special provision.

"T" sections for connecting to median inlets, if required, shall meet the applicable requirements of Article 56.02. Asbestos-bonding, bituminous coating and paved inverts, when specified shall meet the requirements of Article M-170.03.

65.03 CONSTRUCTION METHODS. Construction methods shall meet the applicable provisions of Section 54, with the additional provisions that aluminum pipe shall not be directly coupled to dissimilar metals but shall be separated by a coating such as a bituminous-coated coupling, polyvinyl sheeting, heavy painting with rubber-base paints, or use of aluminized steel.

Aluminum pipe used for syphons, under head or pressure shall be installed in a manner prescribed in Article 54.04 using an aluminum coupling band and with the entire assembly meeting the requirements of these provisions for aluminum culvert pipe.

Culverts to be elongated shall be indicated on the plans.

(A) Field Inspection and Acceptance. The field inspection shall be made by the engineer who shall be furnished by the seller with an itemized statement of the sizes and lengths of culvert pipe in each shipment. This inspection shall include an examination of the culvert pipe for deficiency in nominal specified diameter, net length of finished culvert pipe, and evidence of poor workmanship. The inspection may include the taking of samples for chemical analysis.

The pipe making up the shipment shall fully meet the requirements of

these specifications. If 25 percent of the pipe in any shipment fails to meet these requirements, the entire shipment may be rejected.

65.04 METHOD OF MEASUREMENT. Methods of measurement shall meet the requirements of Article 56.04 with the additional provision that items hereunder will be bid as "Aluminum Culvert," showing diameter and sheet thickness. Also bid hereunder will be "Corrugated Aluminum Pipe-Arch Culvert," such as (43 inch CAP Arch Culvert 0.105 inch), wherein 43 inch is span dimension, and 0.105 inch is the sheet thickness.

65.05 BASIS OF PAYMENT. Corrugated aluminum pipe culverts will be paid for in conformity with Article 54.07. The contract will stipulate only the span dimension, to the nearest inch, of pipe-arch culverts in accordance with standard drawings for such culverts. The plans will carry both span and rise dimensions.

SECTION 69

PIPE UNDERDRAINS

69.01 DESCRIPTION. This work shall consist of constructing underdrains using underdrain pipe and granular filter material, underdrain pipe outlets, and blind drains using granular material meeting the requirements of these specifications and the lines and grades shown on the plans or established by the engineer.

69.02 MATERIALS AND MANUFACTURE. Materials shall be one of the types or kinds meeting the respective requirements of Articles M-160.13, M-160.14, M-160.32, M-160.41, M-170.04 and M-170.06.

69.03 CONSTRUCTION METHODS. Construction methods shall meet the requirements for the pertinent type described in Section 54, except that the bedding material, unless otherwise specified, shall meet the requirements for filter material as specified in Article M-100.12 and set forth on the standard drawings.

Where shown on the plans, the top surface of the filter material shall be shaped as shown and sealed. The sealant may be clay or an artificial mixture composed of asphaltic bitumen or other approved binder.

69.04 METHOD OF MEASUREMENT. Method of measurement for pipe underdrains shall be as provided in Article 54.06.

The filter material will be measured by the cubic yard, the measurement combining the two gradations under one item.

69.05 BASIS OF PAYMENT. Payment for pipe underdrains will be made in accordance with Article 54.07.

Filter material will be paid for at the contract unit price, which price and payment will be full compensation for the work.

The proposed quantity is not guaranteed to be used or required. The State reserves the right to increase, or omit all or any part of the filter material item and no compensation will be allowed by reason thereof.

The furnishing and placing of sealant, will not be paid for directly but be considered included in the contract unit prices for pipe underdrains.

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SECTION 73

IRRIGATION

FACILITIES AND HEADWALLS

73.01 DESCRIPTION. "Irrigation Facilities and Headwalls" shall consist of the furnishing and erection of structures in agreement with these requirements, the specifications, the plans and special provisions.

73.02 METAL DITCH LINING AND FLUME. Metal ditch lining and metal flume shall be made of 0.040 inch thick galvanized ferrous sheets and shall be of semi-circular type. The base metal and spelter coating shall meet the physical and chemical requirements for corrugated metal culvert pipe specified in Article M-170.02. The completed flume or ditch lining shall consist of formed and beaded sheets, carrier rods, compression bars, shoes, anchor rods, nuts and washers, all of which shall be galvanized. The joints between successive sheets comprising the lining shall be designed to provide rigidity and water-tightness, and shall offer the least possible resistance to flow.

Carrier rods, compression and anchor bars, shoes, nuts, washers and hanger plates shall have a galvanized coating of not less than three-fourths ounce of commercially pure zinc per square foot of surface. The coating shall meet the requirements of AASHTO M-218.

The lumber for framing shall meet the requirements of Article M-270.

73.03 DIVISION BOXES. These structures shall be constructed of wood, metal or concrete, as specified, for use in irrigation ditches. They shall meet the requirements of special plans, standard drawings or special provisions whichever may be applicable.

73.04 CONCRETE HEADWALLS AND SUPPORTS. The work contemplated shall be furnishing of materials and performance of work in connection with the construction of concrete headwalls, and supports of various types, meeting the requirements of the contract, plans, standard drawings, specifications or as directed.

73.05 CONSTRUCTION METHODS. The framing, erection and completion of the various timber structures shall be done in conformity with the

appropriate provisions of Section 44 and in conformity with the plans and standard drawings.

Metal ditch lining and metal flume shall be laid true to line and grade, in a bed that is uniformly firm throughout its entire length in accordance with these specifications, and in reasonably close conformity with the lines and grades shown on the plans or as established by the engineer. The separate sections shall be firmly jointed together with the outside laps of circumferential joints pointing upstream.

Excavation shall meet the requirements of Section 52, insofar as applicable or as directed. Methods concerning installation and construction of concrete structures shall meet the applicable requirement of Section 41. Reinforcing steel, when called for, shall be placed as specified by the plans or Standard Drawings. In order to prevent loss of moisture from the concrete, all surfaces which will be in contact with the concrete shall be dampened.

73.06 METHOD OF MEASUREMENT.

(A) Lumber used in the completed and accepted work, other than flashboards and division boxes will be measured in accordance with the respective requirements of Section 44.

(B) Wooden division boxes will be measured by the thousand board feet of lumber used in the completed facility.

(C) Metal ditch lining and metal flume will be measured by the linear foot of the completed and accepted work in place.

(D) Concrete division boxes, flume supports and headwalls will be measured by the cubic yard of concrete in agreement with the applicable provisions of Section 41. Computations for measurements will be to the nearest one-tenth cubic yard. If any reinforcing steel is used, it will not be measured or paid for separately unless specified otherwise and so provided in the contract.

73.07 BASIS OF PAYMENT. Lumber, other than flashboards and division boxes will be paid for at the contract unit price, which price will be full compensation for furnishing the lumber, hauling, handling, framing, erection, and all incidentals necessary to complete the work.

Metal ditch lining and metal flume will be paid for at the contract unit price, which price be full compensation for the work.

Wooden division boxes will be paid for at the contract unit price per M.b.m. which price will be full compensation for the installation of a com-

plete facility. Metal headgates will be paid at the price bid for each; which will be full compensation for the completed facility, including short length of metal pipe or flume when supplied by the manufacturer as an integral part of the headgate.

Headwalls, concrete division boxes and flume supports will be paid for at the contract unit price for concrete in agreement with the applicable provisions of Section 41, which price and payment will be full compensation for the work. If reinforcing steel is incorporated in the structures, payment will be considered as included in the contract unit prices for other items. Payment for flashboards will be included in the contract unit price per cubic yard for the concrete in the structure.

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SECTION 74

CAST IRON PIPE AND CULVERTS

74.01 DESCRIPTION. Cast-iron pipe, designated as cast-iron culvert pipe, cast-iron soil pipe, or cast-iron pressure pipe shall be furnished and installed as specified by the plans or specifications or as directed.

74.02 MATERIALS. Material shall meet the requirements of Article M-170.01.

74.03 CONSTRUCTION METHODS. Excavation and backfill, when necessary, shall meet the requirements of Section 52. The pipe shall be laid in a trench excavated to the lines and grades designated. The bottom of the trench shall be graded and prepared to provide a firm and uniform bearing throughout the entire length of the pipe barrel. Suitable excavation shall be made to receive the bell of the pipe and the joint shall not bear upon the subgrade.

The pipe shall be laid with its spigot end lacking about one-fourth inch of being driven full into the bell. Gaskets and lead shall then be placed, in conformity with good commercial practice, to form a tight joint.

Joints need not be caulked when the pipe is made with approved lock joints or standard mechanical joints, provided the joint is tight.

Pipe installation will be subject to inspection by the engineer, and municipal authorities, where applicable, prior to backfilling. Testing by water under pressure shall be required for pressure pipe.

74.04 METHOD OF MEASUREMENT. The quantity to be paid for under these items will be the number of linear feet (laying length including fittings and joints) of pipe furnished and incorporated in the work in accordance with plans and as directed.

74.05 BASIS OF PAYMENT. Basis for payment will be in accordance with the provisions of Article 54.07. When it is a requirement that joint adequacy be determined by a water test, such testing will be included in the contract unit price for the pipe.

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SECTION 75

CURBS AND GUTTERS

75.01 DESCRIPTION. Curbs and Gutters shall consist of construction of the types of curb, integral curb and gutter, median concrete curb and similar items, furnishing and installing of precast concrete curb, all in accordance with these specifications, the Standard Drawings, the Special Provisions or as directed.

75.02 MATERIALS. When curbs and gutters are made of Portland cement concrete the materials shall meet the requirements of Section 40. Concrete shall be class "DD" unless otherwise specified.

Reinforcing steel shall meet the requirements of Section M-290. Joint material when called for shall meet the requirements of Section M-150.

Materials for bituminous construction shall meet the requirements of Section 30 in regard to aggregate and Section M-120 in regards to bitumen. The bitumen shall be 60-70 penetration asphalt, or the same grade as specified for the plant mix bituminous surfacing. The percent of asphalt used shall be as directed within the limits of 6 and 9 percent and shall be a minimum of one percent greater than the asphalt content of the plant mix bituminous surfacing. The aggregate shall be the same gradation as specified for the plant mix bituminous surfacing or a similar approved gradation.

75.03 CONSTRUCTION METHODS.

(A) General. The top and traffic sides of median curb and other curb serving the same purpose between opposing lanes of traffic shall be uniformly painted with one coat of yellow traffic line paint meeting the requirements of Section M-280 in-so-far as applicable. The curb shall not be painted until allowed to cure at least thirty days after being cast. The paint shall be applied at such a rate that the curb surface is completely covered and hidden. (100 ft. of Type "A" median curb has approximately 115 square feet of surface to be painted).

Slip forms or machines may be used when approved provided these methods will secure a completed product comparable in all respects to that obtained by the set-form method.

When finished, all types of curb and integral curb and gutter shall present clean, uniform surfaces and lines free of irregularities or

distortions. The finished surface shall be in substantial conformity with lines, grades and cross-sections shown on the plans or as established by the engineer. Deviations which prevent drainage or proper joining of subsequent work or detract from the overall appearance of the finished curbing shall be corrected by removing the affected section and replacing it at the contractor's expense. The intent of this specification is to obtain straight, smooth curbing, pleasing to the eye and functional for the purpose intended. Foundations for cast-in-place curb or curb and gutter shall be excavated or otherwise prepared meeting the pertinent requirements of Section 52 and 54.

Forms shall be either metal or straight grained finished lumber. They shall be straight, free of warp or irregularities and of sufficient strength to resist springing or departure from true alignment and grade. Forms shall be full depth, securely staked and braced with headers and clamps. Contact surfaces of forms shall be clean and oiled to prevent adherence of materials and damage in form removal.

(B) Concrete Curb and Gutter. The base on, or cavity in which concrete is placed shall be thoroughly wet, but not muddy, soft or showing pools of water, when the concrete is poured in place. Concrete shall be placed in the forms in uniform layers not to exceed six inches loose depth, with each layer thoroughly tamped and spaded, with approved tools and methods, next to the forms during the placing process to assure uniform maximum density and a smooth surface. All concrete for cast-in-place curbs shall be subject to the limitations of Article 39.07. No concrete shall be placed on a frozen foundation course or subgrade.

As soon as concrete has set sufficiently to retain its shape, forms shall be removed and honey-combed or rough surfaces shall be immediately corrected by use of 1:2 mortar. The concrete shall be floated with a wooden float. All form marks and other irregularities shall be completely removed by floating. Final surface finish shall be obtained by uniformly brushing the surface, using an approved type brush before the concrete sets. The edges of all concrete, including edges at expansion joints, shall be neatly finished to the required radii.

Concrete shall be cured by keeping it wet with water or applying curing compound as specified in Section 40. If water is used, the concrete shall be kept wet for a period of seven days following its finishing.

Unless otherwise specified, precast curb shall conform to all the structural and finish requirements for cast-in-place curb. Precast curb shall be installed in accordance with the requirements shown on the plans and as directed.

(C) Bituminous Curb. The surface upon which the bituminous curb is to be placed shall be thoroughly cleaned and free of extraneous dust and foreign materials. It shall then be primed with SS-1 emulsified asphalt, diluted to a 50-50 blend with water and applied at approximately 0.2 gallons per square yard. The mixture of bitumen and aggregate shall be mixed in an approved pugmill type mixer, at a temperature between 260°F. and 310°F. for not less than 40 seconds. The mixer shall have a capacity not less than 3 cubic feet. The aggregate shall be heated before mixing and shall contain not more than one percent moisture when placed in the mixer.

The mixture of bitumen and aggregate shall be uniformly fed to the extrusion of curb machine at a temperature which will avoid either sloughing of the material or tearing of the surface. The extrusion or curb mixture shall be forced through an orifice or plate by pressure. The machine shall be heated by by ducting exhaust gases or heat from auxiliary burners over the surface of the orifice. The machine shall be mounted on skids to apply sufficient resistance to movement to properly compact the completed product. Material which can not be placed and compacted by the curb machine shall be compacted by mechanical tampers. Backfill shall be so placed as to not disturb the curb.

If bituminous material other than 60-70 penetration asphalt cement is used, a fog coat of SS-1 emulsified asphalt diluted at approximately 50-50 blend with water shall be applied to the finished curb at a rate of approximately 0.20 gallons per square yard.

75.04 METHOD OF MEASUREMENT. Curb, integral curb and gutter, median concrete curb and similar items will be measured by the linear foot along the bottom of the curb line, including radii of completed and accepted work.

75.05 BASIS OF PAYMENT. Curb, integral curb and gutter, median concrete curb and similar items will be paid for at the contract unit price, which price and payment shall be full compensation for the work. "Integral curb and gutter" will be bid as "curb and gutter."

The cost of paint and painting shall be included in the contract unit price for furnishing and installing such curb except when a contract item for painting curb has been included in the contract according to the requirements of Articles 89.06 and 89.07.

The cost of furnishing and applying the SS-1 emulsified asphalt shall be absorbed and included in the contract unit price per linear foot of curb.

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SECTION 76

CONCRETE SIDEWALKS

76.01 DESCRIPTION. Concrete Sidewalk shall consist of furnishing materials and constructing concrete sidewalks meeting the requirements of the contract, specifications, plans and standard drawings or as directed.

76.02 MATERIALS. The materials for Portland cement concrete sidewalks shall meet the requirements of Section 40. Concrete shall be Class "DD" unless specified otherwise.

Reinforcing steel, if used, shall meet the requirements of Section M-290. Joint material when called for, shall meet the requirements of Section M-150.

76.03 CONSTRUCTION METHODS.

(A) Subgrade and Forms. Excavation shall be made to the required depth, thoroughly settled and compacted by wetting and tamping. All soft and unsuitable material shall be removed and replaced with acceptable material. When and as required by the plans, specified aggregates shall be placed and compacted to the required thickness. Forming shall meet the requirements of Article 75.03 and Section 41. The contractor shall use suitable means to assure that grade lines are met and retained.

Wheel chair ramps shall be provided in the areas designated by the plans or the Standard Drawings.

(B) Concrete. Concrete shall be prepared, mixed, placed, jointed, treated, cured and finished meeting the provisions of Section 40. Reinforcing steel, if used, shall be placed as specified by the plans. The base on, or cavity in, which concrete is placed shall be thoroughly wet, but not soft, muddy or showing pools of water, when the concrete is poured in place.

No concrete shall be placed on a frozen foundation course or subgrade. Concrete shall be subject to the limitations of Article 39.07.

76.04 METHOD OF MEASUREMENT. Concrete sidewalks, including wheel chair ramps, shall be measured by the square yard of completed sidewalk. Reinforcing steel and expansion joint material shall not be measured for payment.

76.05 BASIS OF PAYMENT. Payment for sidewalks will be made on the basis of the price bid per square yard. Payment for excavation of material not related to the construction of the sidewalk, but nevertheless necessary before the sidewalk can be placed, when shown on the plans, will be made in agreement with the provisions of Section 11. Otherwise the contractor shall make all excavation, regardless of depth, required for constructing the sidewalk to the lines and grades shown or directed, and shall include all costs thereof in the contract unit price for the item. Payment at the contract unit price shall be full compensation for the work.

SECTION 77

MANHOLES, INLETS, CATCH BASINS, COVERS, RISERS, ETC.

77.01 DESCRIPTION. This work shall consist of the construction of manholes, inlets and catch basins in accordance with these specifications, and in reasonably close conformity with the lines and grades shown on the plans or established by the Engineer.

77.02 MATERIALS. All materials used and all precast structures installed shall meet the requirements specified in the contract or shown on the plans or standard drawings. Concrete shall be class "DD" or equivalent meeting the requirements of Section 40, with the exception that precast concrete manhole riser sections shall have a minimum 28 day compressive strength of 4000 psi. Reinforcing steel shall meet the requirements of Section M-290.

77.03 CONSTRUCTION METHODS. Details of construction and installation of a structure will be stipulated in the contract or shown on the plans.

Excavations shall be made to the required depth and the foundation or base upon which the structure is set shall be in agreement with the lines and grades established by the Engineer. Foundations for the structures shall be prepared in a manner that the structure will have full contact and bearing of its base upon the foundation. Foundations shall be compacted in agreement with the density requirements set forth in Article 11.05.

Backfill around the structure shall be of suitable material deposited uniformly in layers not to exceed six inches in depth with each layer being compacted in accordance with the requirements for density. Extreme care shall be exercised throughout the backfilling process to maintain the structure at the established lines and grades. All structures, inlets, covers and other items specified by the section shall be constructed and installed in agreement with the standard drawings.

Where mortar is required for making connections and for other work necessary, it shall be composed one part Portland cement to two parts

sand meeting the requirements of fine aggregate set forth in Article M-100.01 (A).

77.04 METHOD OF MEASUREMENT. Measurement will be made on the basis of any of the various structures as a unit, including accessories, completed and accepted in place.

77.05 BASIS OF PAYMENT. Manholes, catch basins and inlets, will be paid for at the contract unit price, which price and payment shall be full compensation for all labor, materials, tools and incidentals necessary to complete the item.

Median inlet covers shall be paid for at the contract unit price each, which payment shall constitute full compensation for the inlet covers completed in place.

Necessary excavation and backfill will not be measured or paid for separately, but will be considered to be incidental to and absorbed in the contract unit price for the respective structure.

SECTION 78

PIPE AND TUBING

78.01 DESCRIPTION. Pipe and tubing items shall consist of furnishing all necessary materials, equipment and labor required to complete the installation of steel, copper and wrought iron water pipe.

Items bid under these specifications shall be furnished and installed in agreement with plans and specifications and as directed.

(A) Steel pipe. Black and galvanized seamless steel pipe will be listed on plans as "black steel pipe" or "galvanized steel pipe", with strength, inside diameter and length being shown. It will be listed in a similar manner in the contract.

(B) Copper pipe. Copper tube or pipe will be listed in plans by type with temper, nominal size and length being shown. Similar information is in the contract.

(C) Wrought Iron Pipe. Wrought iron pipe will be listed on plans as "galvanized WI pipe" or "black WI pipe", with strength, inside diameter and length shown. It will be listed in a similar manner in the contract.

78.02 MATERIALS AND MANUFACTURE. Materials for pipe and tubing shall meet the requirements of Article M-170.07, M-170.08 and M-170.09.

78.03 CONSTRUCTION METHODS

(A) Underground. Pipe and tubing installed underground shall be placed in trench or conduit as designated by the plans or as directed. When satisfactorily placed it shall be covered with care to prevent damage. When placed under the highway the pertinent parts of Section 54 shall apply.

(B) Interior and above ground. Pipe and tubing installed interior or above-ground shall be placed as designated by the plans or as directed.

(C) General. All pipe shall be carefully installed in place, connections completed and tested for possible leaks when directed.

78.04 METHOD OF MEASUREMENT. All pipe and tubing will be measured by the linear foot in its final accepted location in the completed system.

78.05 BASIS OF PAYMENT. All pipe and tubing will be paid for at the contract unit price per foot. Payment shall include al necessary labor, materials connections, valves and accessories required to complete the system unless such accessories are listed as contract items. Excavation will be paid for as a separate item in agreement with Article 52.05 unless otherwise specified.

SECTION 80

CHAIN LINK FENCE

80.01 DESCRIPTION. Chain Link Fence shall consist of a chain link wire mesh fence, including gates, supported on pipe framework, furnished and constructed in accordance with these specifications, plans, current standard drawings and as directed. "Steel or iron" will be briefed to "steel" herein.

80.02 MATERIALS. All material used in the construction shall conform to Section M-210.

80.03 CONSTRUCTION METHODS.

(A) Posts. Posts shall be spaced at not more than 10-foot intervals. All intervals shall be measured center to center of posts. In determining the post spacing, measurement will be made parallel to the slope of the existing ground. All posts shall be placed in a vertical position except where designated otherwise.

All posts on five and six foot fence, and the end, anchor line and pull posts on three and four foot fence shall be set in concrete meeting the requirements of Class "F" Section 40 and the dimensions shown on standard drawings. Holes for concrete shall be moistened just before concrete is placed. All concrete footings shall be crowned to shed water. Line posts, except anchor line posts on three and four foot fence shall be driven or set in concrete as field conditions warrant.

Driving shall be accomplished in such a manner as not to damage the post. Voids around the post shall be backfilled with suitable material and thoroughly tamped.

Where solid rock is encountered without an overburden of soil, line posts shall be set a minimum depth of 14 inches, and end, corner, gate and pull posts a minimum of 20 inches into the solid rock. The hole shall have a minimum width or diameter of one inch greater than the largest dimension of the post section to be set. The posts shall be cut, before installation, to lengths which will give the required length of post above ground, or if the contractor so elects he may use an even length of post set at greater depth into the solid rock. Not more than two successive shortened posts shall be set. The third must be full length.

Metal posts placed into holes, which have been bored into rock or

similarly consolidated soils, shall be set and plumbed and the hole filled with grout consisting of one part Portland cement and three parts clean, well graded sand. The grout shall be thoroughly worked into the hole so as to leave no voids. Where posts are set in the above manner, concrete footings will not be required.

Where solid rock is covered by an overburden of soil or loose rock, the posts shall be set to the full depth shown on the standard drawing unless the penetration into solid rock reaches the minimum depths specified above, in which case the depth of penetration may be terminated. Concrete footings shall be constructed from the solid rock to the top of the ground on five and six foot fence and on end, pull and anchor line posts on three and four foot fence. Grouting will be required on the portion of the posts in solid rock.

All posts shall remain solidly in place after backfilling, driving or concreting is completed.

Irregularities in the ground line upon which the fence is being built shall be corrected, as determined and directed, by use of a bulldozer or other equipment that will perform a satisfactory job.

Clearing of trees and brush along the fence line shall be performed by the fencing contractor in conformity with Section 10 unless such clearing has been done by the grading-clearing contractor.

(B) Top Rail — 6 Foot Fence. Top rails shall pass through the ornamental tops of line posts, forming a continuous brace from end to end of each stretch of fence. Lengths of top rail shall be jointed by sleeve type couplings. Top rails shall be securely fastened to terminal posts by pressed steel fittings.

(C) Top Tension Cable — 3, 4, and 5 Foot Fence. Top tension cable shall pass through the ornamental top of the line posts. One continuous length of cable shall be used between pull posts. The cable shall pass through the pull post top and down to the base of the next line post where it shall be attached to the base of the line post with a turnbuckle in the manner shown on the standard drawing. Sufficient tension shall be applied to the cable to allow a maximum sag of one-quarter inch between posts after the chain link mesh has been attached to the cable. The contractor shall provide temporary bracing on pull posts when applying tension to one length of cable at a time, to prevent undue stresses in the pull post.

After tension has been applied to the cables, a wire rope clip shall be placed around both cables, one on each side of the pull posts, and the clips securely tightened. Clips shall be placed as close to the posts as possible to

minimize the deflection of the post if one of the cables should be parted.

The cable shall be fastened to the top of the end pull post with an eye-bolt through the post and a turnbuckle connecting the eye-bolt to the cable. The end pull post shall be braced to the bottom of the end post with a short length of cable attached as shown on the standard drawing. A length of cable shall connect the end pull post and the end post at the top shall be connected to the posts as shown on the standard drawing.

Eye bolts shall have a shoulder on the eye end and shall be provided with a nut and lockwasher. Where the eye bolt is to be installed through a section of pipe, lead washers shall be placed on either side of the pipe. One washer backed by the eye-bolt shoulder and the other washer backed by the lock washer. The nut shall be tightened sufficiently to seal the hole in the pipe.

At each location, where an electric transmission, distribution or secondary line crosses the fence, the contractor shall furnish and install a ground meeting the requirements of Section 9 of the National Electric Safety Code.

A galvanized iron strap one-quarter inch in thickness by two inches in width, formed as shown on the standard drawing, shall be provided for the attachment of eye-bolts to the base of the "H" column post in order to take the strain of the cable tension off the web of the "H" column.

All holes drilled in the post sections shall be cleaned and painted, as hereinafter specified in Part (F) for welded areas on gates, before the eye-bolts are installed.

The ends of all cables shall be seized with annealed iron wire passed around the end of cable and the line cable as shown on the standard drawing. The seizing shall be at least one inch in width.

(D) Fence Fabric. Chain link fabric on six foot fence shall be placed on the face of the post away from the highway, and on 3, 4 and 5 foot fence on the face of the posts designated by the engineer, except that on curves the fabric on all types of fence shall be placed on the face of the post which is on the outside of the curve.

The chain link fabric on six foot fence shall be placed approximately one inch above the ground and on a straight grade between posts by excavating high points of ground. Filling of depressions will be permitted only upon approval of the engineer. The fabric on 3, 4 and 5 foot fence shall be placed above the ground at the height shown on standard drawings.

The fabric shall be stretched taut and securely fastened to the posts. Stretching by motor vehicle will not be permitted. Fastening to end, gate,

corner, and pull posts shall be with stretcher bars and fabric bands spaced at one foot intervals. The fabric shall be cut and each span attached independently at all pull and corner posts. Fastening to line posts shall be with tie wire, metal bands or other approved method, attached at 14-inch intervals. The top edge of the fabric shall be fastened to the top rail with tie wires spaced at 18-inch intervals, or to the top tension cable with tie wires placed at 30-inch intervals.

Rolls of wire fabric shall be joined by weaving a single strand into the ends of the rolls to form a continuous mesh.

When a cattle guard with wings is placed in a line of chain link fence, the wire fabric shall be extended beyond the post supporting the wing to the wing in a neat, workmanlike manner, and securely fastened thereto to the satisfaction of the engineer.

(E) Tension Wire. A tension wire shall be attached to the bottom of the chain link fabric by means of ring fasteners at a maximum of 24 inch intervals and secured at the terminal posts or pull posts by means of brace bands.

(F) Gates. Chain link fabric shall be fastened to the end bars of the gate frame by stretcher bars and fabric bands, and to the top and bottom bars of the gate frames by tie wires in the same manner as specified hereinbefore for the chain link fence fabric, or by other standard methods if approved.

Welded connections on steel gate frames, where the spelter coating has been burned, shall be thoroughly cleaned by wire brushing and all traces of the welding flux and loose or cracked spelter removed. The clean areas shall then be painted with two coats of zinc oxide-zinc dust paint compound in a suitable vehicle in the ratio of one part zinc oxide to four parts zinc dust by weight.

The drop bar locking device for the double metal gates shall be provided with a 12-inch square by 15-inch deep footing of Class "F" concrete crowned at the top and provided with a hole to receive the locking bar. The depth of the penetration of the locking bar into the footing shall be as specified by the manufacturer of the locking device. The height of the gate frame shall be approximately as follows:

6 foot fence — 5 ft. 6 in.

4 foot fence — 3 ft. 6 in.

5 foot fence — 4 ft. 6 in.

3 foot fence — 3 ft. 6 in.

(G) Panels. Panels, made up as described below, shall be installed where indicated by the plans or as directed. The final quantity may vary considerably from plan quantities and the contractor agrees to furnish and

install any final quantity at the contract price, whether more or less than planned. Double-panels, such as may be used at fence corners and angle points, will be composed of, one corner post, two line posts, brace, truss rod, concrete and other miscellaneous fixtures. Single panels such as may be used at gates and fence ends, will be composed of, one gate or end post, one line post brace, truss rod, concrete and miscellaneous fixture.

80.04 METHOD OF MEASUREMENT. Chain link fence will be measured, parallel to the ground, by the linear foot of completed fence, exclusive of openings.

Gates shall be measured for length as the horizontal distance between the inside faces of the two gate posts.

Single or double panels, as described in Part (G) of Article 80.03, will be measured by the unit as installed and accepted when and if panels are a contract item. The fence fabric will be measured as part of the fence. fence.

Dozer time will be measured by the hour. Equipment and operation shall conform to subsection 16.00. Dozer time is to be used in preparing the fence line for building the fence. Other equipment that will produce equal results will be permitted and paid for as dozer time.

80.05 BASIS OF PAYMENT. Payment for the various items listed below shall be full compensation for furnishing all labor, materials, tools and equipment necessary or incidental to the construction of the completed fence and gates, including excavation, backfilling, tamping, concrete footings, smoothing irregularities in the ground along the fence line, clearing the line and disposing of debris — all to the satisfaction of the engineer.

Gates will be paid for by the foot as installed.

Single and double panels will be paid for per each.

Cattle guards shall be paid for on a unit basis, as indicated in the contract and in Section 82.

Use of dozer will be paid for by the hour in conformity with Section 16.00.

Payment for the use of a dozer will be included in the price of the other contract items when this specific item is not included in the contract.

NOTES

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SECTION 81

FENCE

81.01 DESCRIPTION. Work under this specification shall consist of furnishing materials, erecting and constructing new fence, of barbed wire or barbed wire combined with wire mesh, fastened to posts, moving or removing existing fences, constructing and installing gates, moving cattle guards, and performing similar operations, all in conformity with specifications, plans, drawings, and other instruction.

The fence shall be of two general types:

1. Farm fence is intended for use primarily for installation as right-of-way considerations, but it may also be used for frontage road separation and other property line fence or as temporary fence on Interstate highways.

2. Wire fence is generally of a superior quality in comparison to farm fence, and is intended for use primarily for installation on right-of-way boundaries in rural areas on Interstate highways.

The type of fence will be designated on the plans.

A metal gate shall consist of a metal frame filled with wire mesh.

81.02 MATERIALS. All materials used in the construction of the fence and gates shall be new and unused, and shall meet the requirements of Section M-210 and the applicable standard drawings.

81.03 CONSTRUCTION METHODS. Post holes and excavations for footings and anchors shall be excavated on the lines established by the engineer to the depths and cross-sections shown on the standard drawings. Wooden posts may be driven when so prepared and any damaged posts shall be repaired or rejected.

Metal posts which are not required to be set in concrete may be driven. All post hole filling and backfilling work shall be in six inch layers and each layer shall be solidly tamped and compacted as it is placed.

Posts and braces that are cut or trimmed for any valid reason shall be given two coats of preservative material approved by the engineer. Braces shall be securely nailed to terminal and brace posts.

The preservative shall be a minimum of five percent by weight penta- |

chlorophenol solution, or Copper Chromate Arsenate (CCA) type B or C, or Ammoniacal Chromawz Arsenate (ACA), conforming to AWWA standards.

Irregularities in the ground line upon which the fence is being constructed shall be corrected, as determined and directed, by use of a bulldozer or any other equipment that will perform a satisfactory job.

All trees, shrubs, brush, rocks and other obstacles which interfere with proper construction of the fence shall be removed by the contractor and the materials so removed shall be disposed of in a manner satisfactory to the engineer. It is required that the minimum amount of terrain be disturbed in performing this operation.

Any clearing of trees and brush along the fence line shall be performed by the fencing contractor unless such clearing has been done by the grading-clearing contractor.

The contractor is warned that, in such cases as building fences in rocky terrain and the like, the engineer may decide that the slopes of the terrain or finished grading will permit the deletion of some fence from planned quantities. The Department will not be obligated to purchase, from the contractor, any excess materials caused by such deletions or any other deletions which may occur.

Fences crossing drainage courses shall be aligned as shown on the standard drawing.

Deadmen or anchors will be used at grade depressions, angle points and other places where unusual stresses will be exerted on the fence.

Fence panels shall be set at the locations designated. When wooden posts are specified for the fence, a metal line post shall be installed in each 500 foot run of fence, or one metal line post in a run of lesser length between end of gate posts, to serve as lightning protection.

Holes in which concrete is to be placed shall be thoroughly wet when concrete is placed. When posts and braces are set in concrete the concrete must be fully set before fence wire is stretched in place or gates attached. Posts to be set in rock shall be placed as directed. After the posts, braces and footings have been firmly set and established, the woven wire and/or barbed wire shall be placed, tightly stretched and fastened to the post.

All posts shall remain solidly in place after backfilling, driving or grouting has been completed.

Metal posts in rock shall be grouted in place.

Stretching by a motor vehicle will not be permitted; the power must be by or through a mechanical stretcher or device designed for such use.

Tension shall be applied in accordance with wire manufacturer's recommendations.

Fence wire shall be wrapped around terminal posts and fastened to itself with at least four turns. Fence wire, in general, shall be placed on the side of the post opposite the roadway but on curves shall be placed so the force is against the post. At grade depressions and alignment angles, where stresses tending to pull posts from the ground are created, the wire fence shall be snubbed or guyed at the critical points by brace wire attached to each horizontal line of fence wire and the end of the combined strands being firmly attached to a "deadman" buried not less than two feet in the ground, or to an approved "anchor" at a point which will serve best to resist the pull of the wire fence. "Deadmen" also may be fastened to posts. When and where to use "deadmen" shall be as directed, in accordance with the provisions of Article M-210.02(K).

U-shaped staples shall be driven diagonally across the wood grain so that both points do not enter between the same grain. In depressions where wire up-lift occurs, staples shall be sloped slightly upward, against the pull of the wire. On level ground and over knolls, staples shall be sloped slightly downward. Wire shall be stapled tightly at corner, end and pull posts, but on line posts the staples shall not be driven so tight as to prevent movement of the wire. In no case shall staples be driven so tight as to damage the wire.

Gates shall be installed at the location called for by the plans, or as directed.

A cross-fence, not the property of the Department, shall not be fastened to the Department's fence but shall be terminated, in a workman-like manner, adjacent thereto, in conformity with the Standard Drawings.

Upon completion, the fence shall be true to line and grade; all posts shall be vertical and firm and all wire shall be taut and the completed fence shall be completely acceptable in all respects; gates shall operate freely and properly; no openings shall be left that will permit stock or animals to pass through the fence.

81.04 TEMPORARY FENCE. When the plans specify a temporary fence, to exist only during the construction of the project, such fence shall be made of materials and constructed to keep livestock and man-made traffic off the confines of the road being constructed, to an extent satisfactory to the engineer.

The quantity shown for this item is an estimate only and is subject to considerable increase or decrease, dependent upon unpredictable conditions. The engineer reserves the right to increase, decrease, or omit all or

any part of these items and no additional compensation will be allowed for such increase, decrease or omission.

The fence shall comply to Type F3M meeting the requirements of Section M-210 and shown on the standard drawings, using metal posts. Only such braces, panels, deadmen and accessories absolutely necessary shall be used. Other type of fence of reasonably equal effectiveness may be permitted.

Material used in the temporary fence may be used in the permanent fence if it meets all requirements of the specifications and has not been damaged in use. Otherwise the material used in this temporary fencing will remain the property of the contractor.

Removal of temporary fence shall, ordinarily be the duty of and accomplished by the fencing contractor. Whenever in the judgment of the engineer, it becomes necessary for the grading contractor to perform this work in order to facilitate his operations he shall do so when directed.

81.05 REMOVE AND RESET FENCE. When the contract provides for removing and resetting a fence, all required materials, over and above those usable from the fence being moved, shall be new and conform to the provisions of Section M-210.

Rotten, broken posts and rusty, unusable wire shall not be reused but shall be replaced by new material as covered by contract items for new posts and new wire. The quantities of posts and wire specified in the contract are estimated only and are inserted only for the purpose of establishing a price; the final quantities may be considerably more or less and any increase or decrease shall in no way affect the contract price.

Additional fence wire may be used in some cases to fill depressions.

Fence being removed and not reset shall be handled as designated by the special provisions, plans or engineer. When there are materials in such a fence that are worthy of salvage, as determined by the engineer, they shall be carefully handled and placed in stockpile within the confines of the project at locations designated by the engineer.

81.06 METHODS OF MEASUREMENT.

(A) Wire fence, farm fence, temporary fence and fence removed and reset will be measured by the linear foot (converted to the nearest tenth of a rod for payment) complete in place, on its actual alignment, exclusive of gates, cattle guards and such openings. The measurement will be made on the fence line along the top wire, or along a line parallel thereto, from end post to end post, including wing fences to structures, the intent being to

measure the actual length of fence in place. If it is necessary, in crossing depressions, to install a double section of fence, vertically, this extra section will be measured for payment.

(B) Gates shall be measured by the linear foot between gate posts.

(C) Wooden and metal panels as shown on the standard drawings, including incidentals but not including fence wire, shall be considered a unit and bid as such.

(D) Deadmen will be measured by the number installed and accepted. The quantity shown in the contract is an arbitrary quantity for providing a unit price and is subject to substantial increases or decreases, even to none at all. No additional compensation will be allowed because of increase or decrease of contract quantity. When there is no item in the contract deadmen will not be paid for directly but will be considered incidental to and absorbed in payment for the other items of the contract.

(E) **Use of Dozer.** Dozer time shall be measured by the hour. Equipment and operation shall conform to subsection 16.00. Dozer time is to be used in preparing the fence line for building the fence. Any other equipment that will produce equitable results will be permitted and paid for as dozer time.

81.07 BASIS OF PAYMENT.

(A) Combination wire mesh and barbed wire fence shall be paid for on a linear rod basis, measured as specified above.

(B) Gates shall be paid for by the linear foot measured as provided in Article 81.06(B).

(C) Fence panels, as defined above, shall be paid for on a unit basis commensurate with the contract item.

(D) Deadmen will be paid for at the contract price for each deadman accepted in place.

Anchors, as described in this section, will not be eligible for payment as such nor paid for by "deadman items."

(E) Remove fence will be paid for by the linear rod which price and payment shall include the satisfactory removal of all existing fences, when and as directed, regardless of type. The contractor may dispose of the materials in such fences in any manner satisfactory to the engineer, unless the plans or special provisions specify method of disposal.

(F) Move and reset fence will be paid for by the linear rod which price

and payment shall include furnishing all necessary equipment and doing all required work to move and rest an existing fence as specified.

(G) Use of dozer shall be paid for by the hour in conformity with subsection 16.00.

Payment for the use of a dozer will be included in the price of the other contract items when this specific item is not included in the contract.

(H) The removal of temporary fence and panels will not be paid for directly but will be considered to be absorbed in the other contract items.

(I) Unless specifically set forth in the contract, any required clearing of trees and brush along the fence line not accomplished by the grading-clearing contractor will not be paid for separately but will be considered to be a part of and absorbed in the contract unit price for fencing.

Payment for the various items specified above shall be full compensation for furnishing all labor, materials, tools, and equipment necessary or incidental to the construction of the complete fence and gates, including excavation, backfilling anchors, tamping, concrete footings, miscellaneous hardware, smoothing the irregularities of the ground at the fence site, and disposing of all debris all to the satisfaction of the engineer.

81.08 TYPES AND ABBREVIATIONS. Fence and appurtenances shall be placed in several types for administrative and reference purposes. The types shall be as follows:

1. Wire Fence

Single Fence Panel: CW — 2 posts and 1 brace rail.

Double Fence Panel: CW—3 posts and 2 brace rails.

Single Fence Panel: CM—

1 metal post and 1 metal brace, including concrete.

Double Fence Panel: CM—

1 metal post and 2 metal braces, including concrete.

Type CW Wire Fence—

3 barbed wires and 32" woven wire on wooden posts.

Type CM Wire Fence—

3 barbed wires and 32" woven wire on metal posts.

Type CB4M Wire Fence—

4 barbed wires on metal posts.

Type CB4W Wire Fence—

4 barbed wires on wooden posts.

Type CB5M Wire Fence—

5 barbed wires on metal posts.

Type CB5W Wire Fence—

5 barbed wires on wooden posts.

When wire fence (Type F) is specified, the materials shall conform to Article M-210.02.

2. Farm Fence

F2 Farm Fence—Number barbed wire and height of woven wire as specified

F3 Farm Fence—3 barbed wires

F4 Farm Fence—4 barbed wires

F5 Farm Fence—5 barbed wires

F6 Farm Fence—6 barbed wires

F2W means wood posts; F2M means metal posts

Fence Panel—Any type described in Article 81.06(l)

Deadmen—Any type described in Article M-210.02(K) anchors excepted.

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SECTION 82

CATTLE GUARDS

82.00 DESCRIPTION. Cattle Guards shall consist of structures placed in a line of fence, across approaches and roads leading to the roadway, to prevent the straying of livestock onto the highway, but not obstructing the free passage of vehicular traffic. Cattle guards shall be furnished and installed at the locations shown on the plans, or as directed in accordance with the specifications. Each cattle guard shall be equipped with two wings unless specified otherwise.

82.01 MATERIALS

(A) **Concrete.** Bases for cattle guards may be prefabricated according to the requirements of the Standard Drawings. The concrete for poured-in-place bases shall be Class "A", using an air-entraining agent and in conformance with the requirements of Section 40.

(B) **Steel.** Structural and reinforcing steel and hardware shall meet the requirements of Section M-290. Crossbars shall be low-alloy weldable steel meeting the requirements of ASTM A-572, Grade 45 or approved equal. Other steel shall be structural steel meeting the requirements of ASTM A-36. Welding shall meet the requirements of Article 43.06 (H).

(C) **Wings.** Wings connecting the cattle guard to the fence shall meet the requirements of the standard drawing.

(D) **Paint.** Red lead, basic lead silico chromate and aluminum paint shall meet the requirements of Articles M-280.02 (3)(6)(7) or (10) or as otherwise approved.

(E) **General.** A standard manufactured cattle guard of equivalent strength, with suitable clean-out provisions, may be used if approved. All details must be submitted to and be approved prior to fabrication and before footing elevations are set. All designs shall provide for Standard H-20 loading.

82.02 CONSTRUCTION METHODS.

(A) The concrete base shall be constructed to the lines and grades provided in conformity with the standard drawing. Forms used in constructing the base and methods of mixing the concrete shall conform to

the pertinent provisions of Article 41.04 (D), and the standard drawing. Finishing of the concrete shall meet the requirements of Article 41.04 (L), except that stringer bearing surfaces shall be finished to allow full bearing under each stringer. Any uneven surfaces shall be bush-hammered, as directed, until the cattle guard rests on the concrete without rocking or warp.

(B) Cattle Guard. The metal structure shall be placed upon the concrete base indicated by the standard drawing or as directed, and securely fastened thereto.

(C) Wings. The metal wings shall be affixed to the cattle guard and connected to the fence as indicated by the standard drawing.

(D) Painting. All metal parts shall receive one shop coat of red lead paint or basic lead silico chromate paint. Two additional coats are required and they may be applied in the shop or in the field. These additional coats shall consist of a first field coat and one coat of aluminum paint applied in accordance with the requirements of Section 91. During handling or erection, cattleguards shall be handled in such a manner as not to damage or abrade the painted surface. In case painted surfaces are damaged, they shall be properly repainted to the satisfaction of the engineer.

(E) Backfill. Backfill around the completed structure shall be as directed. Clean-up shall be included in requirements.

82.03 METHODS OF MEASUREMENT. Cattle guards shall be measured as a complete unit, as indicated in the contract. The concrete base shall be considered to be a part of the unit.

82.04 BASIS OF PAYMENT. The contract lump sum price for the cattle guard, complete in place, shall be full compensation for the work, ready for use.

SECTION 85

CONDUITS, DUCTS AND PULL BOXES

85.01 DESCRIPTION. This work shall consist of furnishing and installing conduit or duct, whether metallic, cement, fibre or other specified type, in accordance with the specifications, plans, standard drawings, special provisions or as directed, including all required fittings, junction boxes, pull-boxes, accessories and incidentals necessary to place the item in readiness for installation of cables or wiring.

85.02 MATERIALS. Material, except as otherwise specified, shall conform to Section M-310.02.

85.03 CONSTRUCTION METHODS.

(A) Plastic Conduit. Plastic conduit shall be installed where shown on the plans. Plastic conduit **will not** be installed under roadways.

Conduit shall be joined using a solvent welded slip-fitter coupling to make a water-tight joint.

Where plastic conduit runs are placed parallel to other conduit runs or cross over one another, they shall be separated by a minimum of 3 inches of sand or soil cushion. All bending of conduit shall be carefully done to avoid damage. Free ends of conduit shall be capped to prevent the entry of moisture, dirt or rocks.

To allow for expansion and contraction of plastic conduit during installation of long runs, one end must be left unconnected or an "O" ring expansion coupling must be inserted near one end of the run until final covering of conduit is in progress.

Plastic conduit shall terminate a minimum distance of 9 inches outside of pullbox or foundation, and shall be solvent-jointed to a plastic threaded adaptor. A rigid steel conduit bend shall be threaded into the adaptor for entry into pullbox or foundation. The steel conduit ends shall have insulated bushings and shall be electrically bonded.

(B) Steel Conduit. The size and type of conduits, ducts and fittings shall be as shown on the plans. Rigid conduit shall be installed in conformance with Article 346 and thin-wall conduit in conformance with Article 348 of the National Electric Code.

Conduits smaller than one inch electrical trade size shall not be used, unless otherwise specified, except that grounding conductors at service points may be enclosed in one-half inch diameter conduit.

Where pull boxes are installed adjacent to standard base, conduit installed between pull boxes and base shall not be less than 1½ inches in diameter, unless shown otherwise on the plans.

It shall be the privilege of the contractor, at his own expense, to use larger size conduit, and where such is used, it shall be for the entire length of the run from outlet to outlet. No reducing couplings will be permitted.

The ends of conduits shall be well reamed to remove burrs and rough edges. Field cuts shall be made square and true so that the ends will butt or come together for the full circumference thereof. Slip joints or running threads will not be permitted for coupling conduit. When a standard coupling cannot be used, an approved threaded union coupling shall be used. The threads on conduit shall be well painted with a good quality lead or rust preventative paint before couplings are made up. Couplings shall be screwed up until the ends of the conduits are brought together, so that a good electrical connection will be made throughout the entire length of the conduit run. Where coating on conduit has been injured in handling, or installing, such injured places shall be thoroughly painted with rust preventive paint.

Conduit ends shall be threaded and capped with standard pipe caps until wiring is started. When caps are removed, the threaded ends shall be provided with insulated conduit bushings.

Conduit in signal and luminaire pole foundations shall terminate a minimum of three inches from the top of foundation, and six inches from the face of the foundation at a minimum depth of 24 inches from the top of the foundation. Conduit stubs on structures shall be as shown on the plans. Conduit stubs, caps and exposed threads shall be painted with rust-preventive paint.

The locations of ends of all conduits in structures, or terminating at curbs, shall be marked by a "Y" at least three inches high cut into the face of curb, gutter, or wall, directly above the conduit.

Conduit bends, except factory bends, shall have a radius of not less than six times the inside diameter of the conduit. Where factory bends are used, conduit shall be bent, without crimping or flattening, using the longest radius practicable.

Conduit ends, anchor bolts and other fittings which are to be set in concrete shall be placed and securely held in proper position until the concrete sets.

Conduit and duct shall be laid to a depth of not less than 18 inches

below curb grade in sidewalk areas and to a depth of not less than 24 inches below the finished grade in all other areas.

Conduits and ducts placed under railroad tracks shall be installed in conformance with the requirements of the Railroad Company. The contractor shall notify the Department of Highways and the Railroad Company prior to commencing any work on railroad property. This notification shall allow sufficient time to permit representatives of the Department of Highways and the proper Railroad personnel to be present during the work.

Conduits and ducts to be installed under an existing roadway shall be placed by a method approved by the engineer.

When conduits are installed by jacking or drilling, such operation shall be performed in a manner which prevents any damage to the roadway surface. Open cutting of a highway will only be permitted after other methods have failed and then only with the approval of the engineer. Upon the approval of the engineer, small test holes may be cut in the roadway surface to locate obstructions. Jacking or drilling pits shall be kept two feet clear of the edge of any type of roadway surface whenever possible. Use of water to such an extent that a roadway surface might be undermined, or the subgrade softened, shall not be permitted.

When it is necessary to trench across a paved roadway, such trenching will be accomplished in a manner which prevents the mat on the sides of the trench from lifting. The trench will be as narrow as permits safe working conditions.

When asphalt pavements are cut they shall be cut in a manner which will permit a smooth joint to be reconstructed.

Trenches for plastic conduit shall be a minimum depth of 24 inches from the surface to the bottom of the trench. After tamping the bottom of the trench, two inches of sand shall be placed prior to laying the conduit. After placing the conduit sand or soil free from rocks or hard lumps shall be compacted to a depth of six inches above the pipe. The remainder of the backfill material shall not contain stone or aggregate that will not pass a three inch screen. The top one foot of the trench shall be filled with a compacted plant mix. However, if more than one foot of plant mix exists, the replacement asphalt shall equal the thickness of the existing mat.

Backfill material for conduit under the roadbed section shall be compacted to a density of not less than 95% maximum density at optimum moisture content in accordance with Article 11.05.

Backfill material for conduit constructed outside the road bed section shall be compacted to at least the density of the adjacent material.

Conduit terminating in standards or pedestals shall extend approxi-

mately three inches above the foundation vertically and shall be sloped towards handhold opening. Conduit entering concrete pull boxes shall terminate two inches inside the box well and not less than two inches above the bottom, and shall be sloped to facilitate pulling of cable. Conduit entering through the bottom of a pull box shall be located near the end walls to leave the major portion of the box clear. At all outlets, conduit shall enter from the direction of the run. Conduit leading to socket wall or other lights or fixtures below the grade of the pull box shall be sealed by means of an approved sealing compound, to prevent water from flowing to the fixture.

A pull wire shall be installed in all conduits and ducts having a run greater than ten feet, which are to receive future conductors. At least two feet of pull wire shall be doubled back into the conduit at each termination for runs over 100 feet; one foot will suffice for shorter runs.

Junction boxes and conduits shall be installed in the locations shown on the plans and in such manner that the covers, when in place, will be flush with concrete facing or as may be directed otherwise. Installation shall be according to the code and shall form a mechanically and electrically secure continuous system.

Conduit expansion joint, as detailed on the plans, shall be installed where the conduit crosses a fixed or an expansion joint in a structure. Each expansion fitting shall be jumpered with a grounding strap. Contact areas shall be thoroughly cleaned before grounding straps are clamped in place.

Bonding of conduit, lighting bracket anchor bolts and bridge rail anchor bolts, as indicated on the plans, shall be made mechanically and electrically secure to form a continuous system.

Existing underground conduit to be incorporated into a new system shall be cleaned with a mandrel and blown out with compressed air.

Conduit runs shown on the plans are for bidding purposes only and may be changed, with approval of the engineer, to avoid underground obstruction.

Unless specified otherwise, all ducts shall not be less than three inches inside diameter. Pockets or traps which would permit accumulation of moisture will not be permitted. The joints of fibre duct and asbestos cement duct shall be painted with an asphaltic base paint to assure a water-tight joint.

Sufficient length of pull wire shall be left in pull boxes and manholes to bend the drag wire back to prevent its slipping back into the duct. Where spare ducts are installed the open ends shall be plugged with readily removable tapered plugs designed by the duct manufacturer or with a

satisfactory substitute. All ducts shall be securely fastened in place during construction of manholes and pull boxes and plugged to prevent seepage of grout, water or dirt into them. Defective joints shall not be installed. Trenches for ducts shall be excavated manually or with mechanical tenchers. Walls shall be essentially vertical. The trench shall not be more than six inches wider than the outside lines of the duct or ducts. When two or more ducts are installed in a trench, they shall be spaced not less than two inches apart horizontally nor less than six inches apart vertically. The bottom of the trench shall conform to established grade lines and shall be uniformly graded to provide a uniform bearing surface. The duct shall be laid in a layer, at least three inches thick, of dry, fine earth material such as dirt or sand, all of which will pass a quarter inch screen. It shall then be covered with at least three inches of the same type material and firmly tamped in place. When metal conduit is used underground as duct, it need not be as carefully covered as duct but other provisions shall apply.

When duct is to be encased in concrete, materials shall be as shown on the plans or standard drawings.

Existing surfaces, disturbed by duct or conduit installations shall be restored to original type and condition when directed.

(C) Pull Boxes and Manholes. Pull boxes and manholes shall be constructed and installed where shown by the plans or as directed. The contractor may, at his own expense, install such additional boxes that he may deem necessary to facilitate the work. Pull boxes and manholes shall be so installed that the covers will be level with curb, sidewalk or surrounding ground. The bottom of the box shall be bedded in concrete or crushed rock in accordance with the plans or as directed.

85.04 METHOD OF MEASUREMENT.

(A) When a conduit or duct system is bid on a lump sum basis, measurement will be made as a complete system, ready for use.

(B) When conduit or duct is bid by the linear foot, measurement will be made from end to end of each run of conduit or duct, to the nearest foot.

(C) Manholes and pull boxes will be measured on the unit basis as bid.

85.05 BASIS OF PAYMENT.

(A) When a conduit or duct system is bid on a lump sum basis, payment will be made for a complete system, including excavation and incidentals.

(B) When conduit or duct is bid by the linear foot, payment will be made

for the total number of measured linear feet of the item, which payment will include excavation and incidentals.

(C) Payment for manholes and pull boxes will be on the unit basis, including materials, labor, excavation, backfill, crushed rock, extension, and repair of any broken surfaces.

(D) Payment for any and all work and materials bid under this section shall include everything necessary to complete the work in accordance with the plans and specifications or as directed.

SECTION 87

TRAFFIC SIGNALS AND LIGHTING

87.01 DESCRIPTION. The work shall consist of furnishing and installing all necessary materials and equipment to complete the installation of traffic signals, lighting, and other electrical systems. This will include modifying existing systems. All work shall be as shown on the plans or standard drawings and as specified.

87.02 GENERAL. Upon request of the contractor, the engineer will make arrangement with serving the utility for completing service to the project. The contractor shall pay all subsequent fees and energy costs up to the time the project is accepted. Except that the cost of energy used for public benefit, when such operation is ordered by the engineer, will be borne by the Department. Unless indicated otherwise on the plans, or specified, all materials shall be new. Where existing systems are to be modified, the existing material shall be incorporated in the revised system, salvaged, or abandoned as specified in the special provisions, or as ordered. Foundation excavations are to be made and backfilled; concrete foundations are to be constructed; and all improvements and equipment disturbed, damaged, or removed in performing the work, are to be replaced or repaired. The location of signal and light standards, controller pedestals, conduit runs, pull boxes, illuminated signs, and appurtenances shown on the plans are approximate and the exact location will be established by the engineer in the field. All incidental parts which are not shown on the plans, or specified, and which are necessary to complete the traffic signal, lighting, or other electrical systems, or required for modifying existing systems, shall be furnished and installed as though such parts were shown on the plans or specified. All systems shall be complete and in operation to the satisfaction of the engineer at the time of completion of the work.

87.03 REGULATIONS AND CODE. Regulations and code shall meet the requirements of Article M-310.01.

87.04 EQUIPMENT LIST AND DRAWINGS. The contractor shall submit to the engineer for approval, within 20 calendar days of the "Notice to Contractor To Proceed With Work", a complete list of equipment and materials as identified on the plans or in the Special Provisions and which

he proposes to install. This complete list shall show the name of the manufacturer and size and catalog number of the item. The contractor shall submit manufacturer's catalog sheets with pertaining specifications and specific items underlined in red pencil.

The contractor shall submit to the engineer ten copies of Shop Drawings of signal and light poles within 60 calendar days of the Notice to Proceed. It is required that the manufacturer's design calculations be included.

Within 60 calendar days of the Notice to Proceed the contractor shall submit to the engineer copies of purchase orders for major items such as poles, signals, controllers, luminaires and service and control equipment. Such purchase orders shall show the date ordered.

Within 30 calendar days after receiving invoices from the supplier, the contractor shall furnish the engineer copies of such invoices. It is a requirement that the shipping date be shown on these invoices.

Failure of the contractor to submit any of the documents in the above paragraphs, within the specified time limits, will result in the number of days exceeding the specified time limits to be subtracted from the total working days allowed for the completion of the project.

In addition to the above, the contractor shall furnish for approval, six copies of the wiring diagrams for controller cabinets and ten copies of the certified mill test reports on pole material ~~or~~ certification from the manufacturer that pole material and galvanizing meet specifications.

The Department will not be liable for any material purchased, labor performed or delay to the work prior to approval of the documents required above.

All material shall be subject to inspection after delivery to the site and during installation on the project. Failure of the engineer to note defective material or faulty workmanship during construction shall not relieve the contractor of the responsibility for removing or replacing any such material or re-doing work at his own expense. Inspection or sampling of certain materials may be made at the factory or warehouse prior to delivery to the site when required by the engineer. Material which has been rejected previous to delivery shall not be delivered to the project and all material which has been rejected at the project shall be removed from the site.

87.05 MATERIALS. Materials shall meet the requirements of Section M-310 with the exception that paint, unless otherwise specified, shall meet the requirements of Section M-280.

87.06 CONSTRUCTION METHODS.

(A) Section M-310 must be carefully reviewed by the contractor and

engineer as some construction methods are interspersed therein, before starting work on existing series street lighting circuits, the contractor shall obtain daily safety circuit clearance from the servicing utility. Cut-out plugs must be pulled and "Men at Work" signs posted at cut-out boxes before work is done.

(B) Excavating and Backfilling. The excavations required for the installation of conduit, foundations, and other appliances shall be performed in a manner causing the least injury to the streets, sidewalks, and other improvements. The trenches shall not be excavated wider than necessary for the proper installation of the electrical appliances and foundations. Excavating shall not be performed until immediately before installation of conduit and other appliances. The material from the excavation shall be placed in a position where the least damage and obstruction to vehicular and pedestrian traffic and the least interference with the surface drainages will occur. Surplus excavated material shall be removed and disposed of, within 48 hours, by the contractor, outside the highway, subject to the satisfaction of the engineer. The excavation shall be backfilled in conformance with Article 45.03 (F). Excavations after backfilling, shall be kept well filled and maintained in a smooth and well-drained condition, until permanent repairs are made. At the end of each day's work and at all other times when construction operations are suspended, all equipment and other obstructions shall be removed from that portion of the roadway open for use by public traffic. All excavations shall be closed, and sidewalks, pavement and landscaping restored at each intersection prior to opening other intersections, unless otherwise approved. Excavations in the street or highway shall be performed in a manner that only one traffic lane is restricted in either direction at any time.

(C) Removing and Replacing Improvement. Improvements such as sidewalks, curbs, gutters, pavement, bituminous surfacing, base material, and other improvements removed, broken, or damaged by the contractor, shall be replaced or reconstructed with the same kind of materials or with materials of equal quality. The new work shall be left in a serviceable condition satisfactory to the engineer. The outline of areas to be removed in Portland cement concrete sidewalks and in pavements shall be cut to a minimum depth of 1½ inch with an abrasive type saw prior to removing the sidewalk and pavement material. Cut for remainder of the required depth may be made by a method satisfactory to the engineer. Cuts shall be neat and true with no shatter outside the removal area. Whenever a part of a square or slab of existing concrete sidewalk or

driveway is broken or damaged, the entire square or slab shall be removed and the concrete reconstructed as above specified.

(D) Foundations. Foundations for posts, standards, and controller cabinets and the concrete encasement pad for pull boxes shall be Class "D" Portland cement concrete, conforming to the applicable requirements of Section 40.

The bottom of concrete foundations shall rest on firm ground. Foundations shall be poured "in the solid" and monolithically where practicable. The exposed portions shall be formed to present a neat appearance. Forms shall be true to line and grade. Tops of footings for posts and standards, except special foundations, shall be finished to curb or sidewalk grade or as directed. Forms shall be rigid and securely braced in place. Conduit ends and anchor bolts shall be placed in proper position and to proper height, and shall be held in place by means of a template until the concrete has set.

Plumbing of standards shall be accomplished by adjusting nuts before the foundation is finished to final grade. Shims or other similar devices for plumbing or raking will be permitted only on transformer bases. Both form and ground which will be in contact with the concrete shall be thoroughly moistened before placing concrete. Forms shall not be removed until the concrete has thoroughly set. Ordinary surface finish shall be applied to exposed surfaces of concrete. Where obstructions prevent construction of planned foundations, the contractor shall construct an effective foundation satisfactory to the engineer. Posts, poles, standards, and pedestals, except concrete pedestals cast in place, shall not be erected until the foundation has set at least 72 hours, and shall be plumbed or raked, as ordered.

(E) Conductors and Wiring. Conductors shall be run in conduit except where run inside poles. Where signal conductors are run in lighting standards containing high voltage street lighting conductors, the signal conductors shall be enclosed in flexible or rigid metal conduit.

Wiring shall meet the requirements of appropriate article of the code specified in Article M-310.01. Wiring within cabinets, junction boxes, and the like, shall be neatly arranged and laced. Powdered soapstone, talc, or other approved lubricant shall be used in placing conductors in conduit. Signal light conductors, except branch neutrals, shall be run continuously from a terminal block located in a cabinet, compartment, or signal head, to a similarly located terminal block, without splices. Branch signal light neutrals and detector commons may be spliced at pull boxes.

Sufficient signal light conductors shall be provided to perform the

functional operation of the signal system and in addition thereto, two spare conductors of size equal to the largest light conductor in the run, shall be provided throughout the signal light system, except as noted on the plans. At least two feet of slack shall be left for each conductor at each standard (signal or lighting or combined), and at each pullbox.

A common neutral conductor, separate from the signal light circuit neutral, shall be used for all twelve volt circuits such as the pedestrian push-button circuits.

Series lighting cable shall be run without splices from luminaire to luminaire and from service to luminaire. Multiple lighting conductors may be spliced in bases of standards or adjacent pullboxes.

Conductors shall be jointed by a "Western Union" type splice or by the use of an approved connector. Connectors shall be used for splicing all conductors No. 8 AWG, or larger. Splices shall be soldered by the pouring or dripping method.

Acid core solder shall not be used for any splices or connections. Rosin core solder or solid core solder with a rosin paste is acceptable.

Conductor insulation shall be well penciled, trimmed to conical shape, and roughened before applying splice insulation. Splice insulation shall consist of layers of thermoplastic electrical insulating tape not over 0.007 inch thick applied to a thickness equal to and well lapped over the original installation, except that on high voltage and multiple lighting conductor splices, two layers of synthetic oil resistant rubber tape conforming to ASTM D-119 shall be applied over the conductor before placing the thermoplastic tape. The splice shall then be well covered with at least two layers of asphaltic impregnated open mesh fabric tape, and a coating of high grade insulating paint or similar material. At least two feet of slack shall be left for each conductor at each splice.

Where multi-conductor cable is used, conductor splices shall be neatly cabled together and covered with a hot vulcanized layer of material suitable to bond with the cable covering. When finished, the joint shall present a covering built up level with original cable covering and shall be completely waterproof. An approved type of watertight splicing box may be used in lieu of vulcanizing.

When conductors and cables are pulled into the conduit, ends of conductors and cables shall be taped to exclude moisture, and shall be so kept until the splices are made or terminal appliances attached. Ends of spare conductors shall be taped.

A small permanent band or bands, on which the circuit, designation number, and phase are stamped, in the order named, using the code letters given in Article M-310.05 (E) shall be securely attached near the

end of each conductor, at each controller, switch, standard, or pull box, where conductors are separated. Where circuit and phase are not clearly indicated by conductor insulation, additional bands shall be used at controller cabinets and signal poles. Cables shall be tagged to show their routing.

In the installation of span wire suspended signals on overhead guys, enough sag should be allowed so the strain poles are not overloaded. The recommended sag is five percent of the total span distance. Steel strain poles should be installed with enough initial rake away from the strain so that the poles will be plumb when all attachments are made. The overhead guy with signals attached should be raised into place to, but not beyond the desired sag. Adjustments interact and it may be necessary to adjust the mounting height of guy at either or both poles, sag, and rake of poles, so that when completed the signals are the desired height above roadway with proper sag and the poles plumb.

(F) Bonding and Grounding. Metallic cable sheaths, conduit, and metal poles and pedestals shall be made mechanically and electrically secure to form a continuous system, and shall be effectively grounded. Bonding and grounding jumpers shall be copper wire or strap of the same cross sectional area as No. 6AWG. Bonding of standards and pedestals shall be by means of a bonding strap attached to an anchor bolt or a three sixteenth inch, or larger, brass or bronze bolt installed in the lower portion of the shaft. One side of the secondary circuit of series-multiple transformers shall be grounded. Grounding of conduit and neutral at service point shall be accomplished as required under the code or this section, except that grounding conductors shall be No. 6 AWG, or equal.

At each multiple service point, a ground electrode shall be furnished and installed. Electrodes of non-ferrous materials, or their approved equivalent, shall not be less than five-eighths inch diameter. Ground electrodes shall be installed in accordance with the code. The service equipment shall be bonded to the ground electrode by use of a ground clamp and No. 6 AWG copper wire, or equal, enclosed in a one-half inch diameter conduit or hardwood moulding. Where conduit system parallels, or crosses, a permanent water system in accessible areas, grounding jumpers shall be installed at intervals not exceeding 500 feet. Grounding to a water system at or near the service point will be accepted in lieu of the driven ground rod.

(G) Service Connections. Service points shown on the plans are approximate only. The contractor shall determine exact locations from the serving utility. Where the contractor is required to install the lower section

of riser on a utility pole, the location of riser shall be determined by the utility.

87.07 PAINTING. Paint may be applied at any time approved by the engineer. Standards, frames, signal bridges, fittings and other applicable metal parts shall be thoroughly clean when paint is applied. Breaks, abrasions and damaged areas on galvanized surfaces shall be painted with lead silica-chromate primer and two coats of aluminum paint meeting the requirements of Article M-280.02 (7) and (3) respectively.

If the manufacturer has applied an approved prime coat of paint, and it is not damaged, field primer will not be required.

Galvanized surfaces, which are to be painted, shall be treated as follows:

In one gallon of soft water dissolve two ounces each of copper chloride, copper nitrate, and sal ammoniac, then add two ounces of commercial muriatic acid. This should be done in a earthen or glass vessel, never in tin or other metal receptacle. Apply the solution with a wide flat brush to the galvanized surface, when it will assume a dark, almost black color, which on drying becomes a grayish film.

One coat of Red Lead or Basic Lead Silico-Chromate Paint meeting the requirements of Item (6) and (7) Article M-280.02 shall be applied as a prime coat.

After erection, all exterior surfaces shall be examined for damaged primer and such damaged surfaces shall be given a spot coat of primer.

Two coats of enamel shall be applied as specified in Article M-280.02(14) of the standard specifications. Enamel color shall be as outlined below.

Signal heads and fittings, when factory enameled, black, dark olive green, or yellow, and when in good condition, will not require further painting. If signal heads are unpainted, or in poor condition, one coat of primer and two coats of enamel shall be applied. Mixing of colors, for the same intersection, will not be permitted.

Backplates shall receive one coat of primer.

Interior of hoods and front faces of backplates shall be finished with two coats of flat black enamel.

Controller cabinet exteriors if factory enameled dark olive green, yellow, or aluminum, when in good condition, will not require further painting. Unpainted cabinet exteriors shall receive one coat of primer and two coats of enamel.

Poles, which are used for lighting only and are galvanized, will not require painting except as required to repair damaged surfaces.

Concrete guard posts shall be painted with one coat of primer and two coats of signal post yellow enamel. Treated wood guard posts need not be painted.

All paint coats may be applied either by hand brushing or approved spraying machines in the hands of skilled operators. The work shall be done in a neat and workmanlike manner, and the engineer reserves the right to require the use of brushes for the application of paint, should the work done by the paint spraying machines proves unsatisfactory or objectionable.

87.08 FIELD TEST. Prior to completion of the work, the contractor shall cause the following tests to be made on traffic signal and lighting circuits, in the presence of the engineer.

(1) Test for continuity of each circuit.

(2) Test for grounds in each circuit.

(3) A megger test on each circuit between the circuit and ground. The insulation resistance shall not be less than the values specified in Section 11.19 of the code specified in Article M-310.01.

(4) A functional test in which it is demonstrated that each and every part of the system functions as specified or intended herein.

(5) The contractor shall perform, on high voltage series lighting circuits, a high voltage test consisting of an 8,400-volt, 60 cycle alternating current between the conductors and ground for five consecutive minutes with the two ends of the circuit connected together. The initially applied voltage shall be applied to the entire completed circuit and shall not be greater than the rated voltage of the cable and the rate of increase shall be approximately uniform not over 100 percent in ten seconds nor less than 100 percent in 60 seconds. The voltage shall be increased to the value of 8,400 volts root mean square and held at this value for five minutes.

When approved by the engineer, the contractor may, in lieu of the above 8,400-volt, perform a high voltage series lighting test consisting of the open circuit voltage of the connected constant current transformer between the conductors and ground.

Faults in any material or in part of the installation revealed by these tests shall be replaced or repaired by the contractor in a manner approved by the engineer, and the same test shall be repeated until no fault appears.

87.09 SALVAGING AND REINSTALLING ELECTRICAL EQUIPMENT.

(A) **Salvaging Electrical Equipment.** Where shown on the plans or

directed, existing electrical equipment including controllers, cabinets, signal heads, luminaires, standards, pull boxes, and detector frames and pads, and the like shall be removed, cleaned, salvaged and stockpiled and reinstalled as specified.

Unless otherwise specified, underground conduit, conductors, bases and detector frames not reused shall become the property of the contractor and shall be removed, except, if not interfering with other construction, said materials, may with written approval, be abandoned in place.

Care shall be exercised in removing and salvaging electrical equipment so that it will remain in its original form whenever possible. The contractor will be required to replace, at his own expense, any of the above-mentioned electrical equipment, which, as determined by the engineer, has been damaged or destroyed by reason of his operation.

(B) Reinstalling Salvaged Electrical Equipment. When salvaged electrical equipment is to be reinstalled, the contractor shall furnish and install all necessary materials and equipment, including anchor bolts, nuts, washers, concrete, and the like, required to complete the new installation.

87.10 METHOD OF MEASUREMENT. When a lighting or signal system is bid on a lump sum basis, measurement will be made as a complete system.

Items which are bid on a linear foot basis will be measured to the nearest linear foot in place, ready for use.

Items which are bid on a unit basis will be counted as such.

87.11 BASIS OF PAYMENT. When a lighting or signal system is bid on a lump sum basis, payment will be made for a complete system.

When items are bid on a linear foot basis, payment will be made for the total number of measured linear feet of the item.

When items are bid on a unit basis, payment will be made for the counted quantity.

Payment for work and materials bid under this section shall include everything necessary to complete the work in accordance with the plans and specifications and as directed.

Payment for various types of signals will include "mounting".

NOTES

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SECTION 88

SIGNS AND SIGNING

88.01 DESCRIPTION. "Signs and Signing" shall consist of furnishing all materials, making and preparing all signs and performing all incidental work. This will include erection, installation, fittings, posts, foundations, structures and the like, meeting the requirements of the plans, standard drawings, specifications and special provisions and as directed.

It is the intent of these specifications to comply with the standards and requirements of the "Manual on Uniform Traffic Control Devices for Streets and Highways" as adopted by the Federal Highway Administration and the design requirements of the current AASHTO manuals.

All signs specified shall meet the requirements of the MUTCD Manual and the Montana Sign Index as modified by the Standard Drawings. Details of standard sign faces are to be found in the F.H.W.A. Manual "Standard Highway Signs" and in the Standard Drawings. For signs that are larger or smaller than those detailed, the legend will be increased or decreased in size proportionately.

88.02 MATERIALS. Materials for signs shall meet the requirements of Section M-320.

88.03 CONSTRUCTION METHODS. All signs shall be located and erected as shown on the plans, except the engineer may change a sign location where necessary to secure an acceptable location.

Signs shall normally be erected so the sign face is truly vertical and at the alignment with the oncoming traffic as shown on the plans and standard drawings.

After installation of signs is complete, they shall be inspected at night by the engineer. If specular reflection is apparent on any sign, its position shall be adjusted by the contractor to eliminate this condition.

Post, pole or foundation holes shall be augered or dug a minimum of eight inches larger than the largest diameter of the pole or post to be placed in it. In backfilling the holes for sign posts or poles the contractor shall thoroughly mix with the material removed from the hole, Portland cement in the ratio of one part of cement to ten parts of the material from the hole. Cement and material removed from the hole shall be mixed in a mortar box or other container large enough to thoroughly blend the

mixture. Enough water shall be added to make a soil-cement mixture capable of achieving satisfactory compaction. No mixing shall be done in the hole. After the pole is placed in the hole — WITHOUT THE SIGN ATTACHED — backfill material shall be placed uniformly in the hole in lifts of not more than eight inches in thickness and thoroughly compacted. Compacting may be done by hand tamping or mechanical methods sufficient to achieve adequate density. The curing time shall be seven days, after which the sign may be affixed to the post or pole.

The contractor may elect to use class "F" concrete to backfill the hole with timber posts or poles. Foundations holes for steel sign posts shall be backfilled with class "A" or "D" concrete, finished flush with the ground, pavement, or sidewalk. Signs shall not be affixed to posts or poles set in concrete until seven days have elapsed following placement of the concrete.

All welding of metal joints and breaks shall meet the requirements of Section 43.

Signs shall be completely fabricated, including sign legends, before delivery to the project, with the exception of signs which are too large to transport to the project in one piece.

88.04 PARTIAL COMPLETION & PROGRESS PAYMENTS. Signs and other traffic guidance devices, named or described herein, will be accepted, individually or in groups, as "completed facilities" when completely installed in accordance with the plans and specifications. Such signs shall be taken over for maintenance by the Department and the contractor will be relieved of further liability except for damage inflicted by him or his forces.

Delineator posts with reflectors will be accepted in increments of 100 or more units, put in service as guidance facilities.

Small guidance, directional and warning signs, up to a surface area of ten square feet on one side, will be accepted when 25 or more such signs have been placed in service.

Medium signs, up to a face area of 30 square feet on one side, will be accepted when five or more such signs have been placed in service.

Overhead structures and signs larger than 30 square feet in face area, will be accepted individually when placed in service.

The extent and method of payment will be in accordance with Article 09.06 of the standard specifications with each completed and accepted facility credited to the contractor at the contract unit price on progress estimates.

88.05 METHOD OF MEASUREMENT.

(A) **Aluminum Signs.** Aluminum sheet and aluminum sheet increment signs will be measured to the closest one-tenth square foot of the sign face as accepted complete in place.

(B) **Plywood Signs.** These will be measured to the closest one tenth square foot of the sign face accepted complete in place.

(C) **Metal Posts.** The poundage to be paid for shall be the number of pounds of metal in each post calculated from the nominal weight per foot times the length of each post, plus the break-away device, fuse plate, stub post, post clips and mounting angles as shown on the plans or modified by the engineer, complete in place in the concrete footing and accepted. The poundage of tapered posts and posts of non-uniform section shall be paid for in accordance with invoice weights.

(D) **Treated Timber Posts.** Timber posts complete in place according to the plans and these specifications, will be measured separately by the thousand board feet measure. Measurements will be computed from the dimensions shown on the plans or modified by the engineer. Accepted commercial timber sizes and lengths for each post will be used as basis of measurement.

(E) **Treated Timber Poles.** Treated timber poles will be measured in even two foot increments. When the measurement of an installed pole falls between increments, payment will be made for the higher increment.

(F) **Lump Sum.** When a signing system is bid on a "lump sum" basis there will be no direct measurement unless specified otherwise.

(G) **Delineators.**

(1) All types and kinds of delineator reflectors shall be measured by the number installed and accepted. Delineator reflectors measured for payment shall include the reflectors, reflective sheeting, mounting plates or straps, nuts and bolts or other approved or specified fastener devices and all miscellaneous hardware necessary to complete a reflector assembly and fasten it to a post.

(2) Delineator (Metal U) posts will be measured by the lineal foot installed and accepted.

88.06 BASIS OF PAYMENT. Highways signs and signing will be paid for at the contract unit price, which price and payment will be full compensation for completing the work in an acceptable manner. The contract prices for the various component parts shall include concrete for

foundations, all miscellaneous hardware, equipment use, back bracing and other incidentals that may be required.

When a signing system is bid on a "lump sum" basis, payment will be made accordingly.

SECTION 89

PAVEMENT MARKINGS AND MARKERS

89.01 DESCRIPTION Pavement Markings and Markers shall consist of furnishing the material and performing the work as necessary to paint those lines, words or symbols, or affixing to the pavement those plastic lines, words, symbols or channelization buttons or other reflective markers as specified by the plans, standard drawings, standard specifications, special provisions or as directed.

It is the intent of these specifications to comply with the standards and requirements of the "Manual on Uniform Traffic Control Devices for Streets and Highways," "Standards for Pavement Markings" as adopted by the Federal Highway Administration and the Department of Highways.

89.02 MATERIALS. The reflectorized plastic pavement markers and legends shall consist of a homogeneous, extruded, pre-fabricated, thermo-plastic ribbon of specified thickness and width, which shall contain reflective glass spheres uniformly distributed throughout the entire cross-section, and shall be capable of being affixed to bituminous or cement-concrete pavements by means of a pre-coated adhesive and pressure as herein specified.

As supplied, the plastic without precoated adhesive shall be not less than 0.09 inches in thickness. The edges shall be clear cut and true.

Plastic shall be supplied complete with a precoated adhesive and an easily removable backing shall protect the adhesive in storage and facilitate rapid application.

The precoated, tack-free, pressure-sensitive adhesive shall be in nature a rubberized tar type binder (chemically curing within minutes after application) uniformly smooth distributed (extruded) to the plastic with not less than one-sixteenth of an inch thickness at any given place and it must comply to all of the specifications set forth. Plastic Pavement Markings shall meet the requirements of Article M-320.03.

The plastic and its adhesive shall be sufficiently free of tack so that it can be easily handled without the protective backing, and be repositioned on the surface to which it is to be applied before permanently fixing it in this position with a downward pressure.

The plastic marker shall mold itself to pavement contours, breaks, faults, and the like, merely by traffic action at normal pavement

temperatures. The plastic marker shall have resealing characteristics such that it will fuse with itself and with previously applied markings of the same composition under normal conditions of use.

All plastic pavement markers on new asphalt pavement shall be in-layed as described in Article 89.03.

Pavement legends and symbols must conform to the applicable shapes and sizes outlined in the "Manual on Uniform Traffic Control Devices for Streets and Highways" as adopted by the F.H.W.A. Administrator.

Bids will be considered only from manufacturers of reflectorized plastic pavement markers and legends who can submit evidence of successful product use over the past five years, under similar climatic conditions. Agents or distributors of products are required to state manufacturer and trade name of product bid upon and must comply with the successful use requirement.

Paint and glass beads shall meet the requirements of Section M-280.

89.03 CONSTRUCTION METHODS.

Existing Construction Surfaces: It is intended that application of plastic materials be made on clean, dry pavement surfaces free of dirt and foreign matter, simply by removing the release paper and placing the plastic on the surface with continuous pressure for a period of about 30 seconds, then permitting traffic to pass over it. The pavement temperature shall be 60° F. or higher. Without activator, plastic is applied as follows: 1. Remove release paper. 2. Apply plastic to pavement. 3. Apply pressure using a weighted roller. 4. Open to traffic. Special instructions shall be supplied for application at temperatures below 60° F. See special procedure (b).

When plastic require activators for the adhesive or various special coatings for different pavement surfaces, the pavement temperature shall be 45° F., or higher with activator. Plastic is applied as follows: 1. Remove release paper from adhesive. 2. Apply solvent* with a spray gun applying a light mist to the road surface or adhesive approximately three feet in front of the plastic application. The road surface should be wetted by the solvent to absorb the dust which tends to reduce the adhesion of the adhesive. The solvent will also soften the adhesive for lower temperature application. 3. Apply plastic to the pavement. 4. Apply pressure using a weighted roller. 5. Open to traffic as soon as adhesive has taken hold, a matter of a few minutes depending on the temperature.

NOTE:—Use traffic to roll plastic when possible. Never apply plastic to wet surface because dampness and water reduce adhesion.

Recommended Solvents*Flammable Type**

Gasoline

VM&P Naphtha

Non-Flammable Type

Trichloroethylene (Degreasing grade)

Perchloroethylene (Degreasing grade)

New Construction Surfaces: If a sealer has been used on the road surface then the surface to receive the plastic must be precleaned to neutralize any acid and remove the sealer. Recommended Cleaner: 5% phosphoric acid.

New asphalt or cement surfaces must be of a relative smooth horizontal pavement texture. A prior to application inspection (in writing) of the surface must be made by the State Field Project Manager and the Products Manufacturers Factory Employed Representative to approve (or reject) the surface for proper application. In the event of a rejected surface, preparation must be performed to meet the recommendations set forth by the inspectors.

On new and existing old surfaces all application crews (maintenance or contractual) must be thoroughly trained in proper application procedure of plastic by the Manufacturer's Factory Employed Representative.

Should plastic require activators for the adhesive or various special coatings for different pavement surfaces, detailed information must be supplied with the bid indicating special application procedures.

Application Inlay for New Asphaltic Surface: The plastic shall be capable of being applied to new asphaltic pavement immediately prior to the final rolling of the new surface, and of being rolled into place with conventional pavement and highway rollers.

The pavement temperature shall be 60° F. or higher.

The plastic and adhesive shall be of the type that the water used on the road roller to prevent asphalt pick-up, shall not be harmful to the successful application of the plastic.

Packaging: The plastic will be furnished in either four-inches or six inches by 150-foot rolls, packaged in center mandrel cartons. The package must be designed so as to allow for easy dispensing of the strips through a slot in the end of the carton.

Plastic Pavement Markings shall meet the requirements of Article M-320.03, the plans, the special provisions or as directed.

89.04 PAINTING TRAFFIC LINES. The surface to be painted shall be swept clean and free of dirt, rocks, gravel and any other foreign matter. The paint shall be applied by hand or mechanical means consistent with

the scope of the job. The width and layout of stripes, or the area to be painted shall conform to plans or standard drawings. Means satisfactory to the engineer shall be adopted to keep traffic off the paint until it has properly set and will not pick up.

The top and traffic sides of median curb and any other curb serving the same purpose between opposing lanes of traffic shall be uniformly painted with one coat of yellow traffic line paint conforming to Article M-280.02 and with the above insofar as applicable. The curb shall not be painted until allowed to cure at least thirty days after being cast. The paint shall be applied at such a rate that the curb surface is completely covered and hidden. (100 ft. of Type "A" Median Curb has approximately 115 square feet of surface to be painted).

Prior to applying paint, the contractor shall mark the roadway between control points established by the Engineer. The Engineer will establish such control points on tangent at least every 500 feet and points on curves at least every 100 feet for under two-degree curves and at 50-foot intervals on curves over two-degree curvature. The contractor shall maintain the line within two inches of the established lines. The Engineer shall also designate other pavement striping locations such as stop bars, crosswalks and the like. The Engineer will use the Montana Highway Department Manual for Pavement Markings to lay out the work for the contractor.

Highway traffic striping shall be applied during daylight hours and only when the air and pavement temperature are 40° F. or higher and the pavement surface is dry and the weather is not foggy, rainy or stormy.

Paint and glass beads shall be applied with equipment manufactured specifically for that purpose and only by workmen experienced in operating such equipment. The bead applicator shall be located directly behind and synchronized with the paint applicator. Both devices shall be properly shielded to avoid spraying of paint or loss of beads outside of the designated width of line. The equipment shall also be capable of painting a stripe, or stripes of the desired width with a tolerance of plus or minus one quarter inch. In areas of "no passing zones," the machine shall be capable of painting three stripes simultaneously. For centerline painting the machine shall be equipped with an automatic skip control giving a 15-foot painted segment and a 25-foot gap within a linear tolerance of six inches over that cycle.

Adequate hand-operated equipment will be required to accomplish the striping for stop bars, crosswalks and other areas not readily accessible to the pavement striping machine.

The pavement striping machine shall be adjusted to apply the paint at the following rates per gallon:

Four-inch solid stripe—at least 250 but not more than 275 lin. ft.

Four-inch dashed stripe—at least 665 but not more than 735 lin. ft.

For narrower or wider striping, paint shall be applied at a rate in proportion with the four-inch stripes.

Beads shall be applied at the rate of six pounds per gallon of paint, plus or minus one tenth pound.

For quality control, the Engineer will check the application at the beginning of each day's paint striping and as often thereafter as considered by him to be necessary. If equipment settings fail to produce quality striping within the limits specified, striping shall be stopped until the cause of the trouble is corrected.

The contractor shall protect the markings until dry by placing approved guarding or warning devices wherever necessary. Any markings smeared or otherwise damaged shall be corrected at no expense to the Department. Painting of Pavement Markings shall also meet the requirements of the plans, the special provisions or as directed.

89.05 REMOVAL OF PAVEMENT MARKINGS. As directed by the engineer the contractor shall remove temporary pavement markings or markings which are no longer appropriate to the roadway.

Pavement markings shall be removed by grinding or by any other means which will remove (not cover) the markings to the satisfaction of the engineer.

89.06 METHOD OF MEASUREMENT Pavement Markings and Markers will be measured as follows:

Plastic Pavement Markings will be the number of linear feet of four inch line, or incremental equivalents of width thereof (e.g. a five inch width is the actual measured length times 1.25), or square feet of words and symbols, measured in place and accepted.

Length of dashed longitudinal pavement lines shall be the actual length placed or painted, e.g., (37.5% of total roadway length where 15-25 paint-gap ratio is used). Plastic lines are based on four inch widths. Any variance is pro-rated as above.

When painting of traffic lines and words and symbols is specified as a bid item, measurement will be the actual gallons of paint used and accepted and shall include the furnishing and application of glass beads.

89.07 BASIS OF PAYMENT Payment for Pavement Marking and Markers will be as follows: When Plastic Pavement Markings are specified as bid items, payment will be the actual, or pro-rated, number of Linear feet of

four inch line or square feet of words and symbols applied and accepted in place, which price and payment shall be full compensation for furnishing all necessary materials and equipment and doing all required work.

The work required for removal of pavement markings will not be paid for directly but will be considered incidental to and absorbed in payment for the other items of the contract.

Painting of traffic lines and Words and Symbols will be paid for at the contract unit price per gallon for "Highway Traffic Striping" complete in place, including the furnishing and application of beads. Payment will be full compensation for all work necessary to complete the item.

The cost of paint and painting the top and traffic sides of median curb and any other curb, serving the same purpose, shall be paid for at the contract unit price per gallon for Curb Marking.

Painted Markings will be paid for as itemized by the schedule below.

ITEM	BASIS OF PAYMENT
Curb Marking	Gallons
Yellow Paint Stripe	Gallons
White Paint Stripe	Gallons
Yellow Painted Words & Symbols	Gallons
White Painted Words & Symbols	Gallons
Plastic Stripe (All Colors)	Linear Feet
Plastic Words & Symbols (All Colors)	Square Feet

SECTION 90

TRAFFIC GUIDANCE DEVICES

SUBSECTION 90.00 GUARD RAIL AND MEDIAN BARRIER RAIL.

90.01 DESCRIPTION "Guard Rail and Median Barrier Rail" shall consist of the furnishing and installing of metal beam guard rail or, metal or concrete median barrier rail as stipulated in the contract and meeting the requirements of the plans, standard drawings, special provisions and standard specifications.

90.02 MATERIALS. Metal Beam guard and median rail shall meet the requirements of Article M-220.01. Concrete Median Rail shall meet the requirements of the plans, standard drawings and special provisions.

90.03 CONSTRUCTION METHODS.

(A) General. Posts shall be set to line and grade. The engineer will establish line and grade for the terminal end sections. It shall be the contractors' responsibility to establish line and grade between the terminal end sections. However, during construction of the guard rail the engineer will make visual spot-checks of the work in progress to assure that the rail elements and posts are being installed in a manner which will produce a smooth and continuous appearance of the finished installation. Any weaving of alignment or sags in elevation shall be corrected as directed.

Excavation, punching or post driving methods and equipment are subject to approval. Methods or equipment will be prohibited if their use causes excessive displacement of the surrounding material or damages adjacent paved surface or results in unacceptable work.

Placement operations that cause the adjacent paved surface to heave more than one-half inch in ten feet, measured with a ten foot straight edge parallel to the pavement shall be stopped. Material around each post, if damaged, shall be repaired and leveled to the satisfaction of the engineer.

All pavement within a two foot radius of intended post location shall be neatly removed before driving posts, and before excavating or punching if posts are placed after the paving operations. After the posts are installed, the pavement shall be replaced with new paving material compacted to approximately the same thickness and to the same level as the adjacent pavement. The guard rail shall contact the posts firmly with even bearing.

(B) Post Placement by Excavation and Backfill. Guardrail posts placed by this method shall meet the following requirements:

Post holes shall be a minimum of 18 inches in diameter, unless otherwise approved.

Backfilling, of posts in dug holes, shall not begin until the bottom of the excavated hole is thoroughly tamped. During backfilling and tamping operations the posts shall be maintained in the correct position at the established line and grade. Backfill material shall be placed around each post in successive layers, approximately 0.5 foot loose depth. Each layer is to be firmly tamped before the next layer is placed. Tamping shall be done by power methods. Water shall be used if directed.

(C) Post Placement by Driving. If driving is permitted, the work shall meet the following requirements:

Either steel or wood posts may be driven.

Caps, fitting the shape of the top of the post, shall be used in driving.

Corrections in post alignment shall be made as needed during driving and before the post is driven completely.

Small gaps between the soil and the post shall be corrected by tamping or backfilling and tamping. Loose material around the post shall be thoroughly re-compacted and the area leveled as directed.

Posts that are mis-aligned, loose, or otherwise unacceptable after driving shall be removed and re-installed in accordance with paragraph (B) of this article.

A pilot hole, approximately six inches in diameter, may be used if approved, if satisfactory results cannot be obtained when driving posts in shot rock or extremely gravelly material.

(D) Metal Beam. The rail unit shall be spliced by lapping in the direction of traffic. All splices must be made at a post. The rails at the splice shall make contact throughout the area of splice.

Median barrier rail shall be constructed in accordance with applicable standard drawings. Median barrier rail is composed of the same specified elements which comprises beam guard rail, except that there is a railing on each side of the post, presenting a barrier toward each roadway. The terminal section shall be specially designed for the purpose. A galvanized metal or aluminum alloy washer, shaped to reasonably conform with the form of the metal railing, shall be used under the nut which goes on the threaded end of the bolt which holds the rail to the post. The type of rail and post shall be as specified.

Bolts through joint and mounting bolts shall be drawn up as tight as

possible without being tight enough to prevent the rail elements from sliding past one another longitudinally.

Bolts shall be sufficiently long to extend at least one quarter inch beyond nuts and no appreciable projection will be allowed which will obstruct a vehicle sliding along the rail.

After erection, all abrasions on metal parts shall be spot painted in accordance with the provisions of Article 91.06 (B)(4)(c). The finished sections in place shall be free from bruised, broken, scaled or otherwise damaged spelter.

(E) Concrete Median Barrier. Concrete Median Barrier shall be installed in accordance with the requirements of the plans, standard drawings or special provisions.

90.04 METHOD OF MEASUREMENT Guard rail and median barrier rail will be measured to the nearest one-tenth linear foot from center to center of the end posts of each section.

The length of median rail shall include the rail on both sides. Terminal sections of beam guard rail will be considered as necessary accessories, unless provided otherwise in special cases. Measurement will not be made for end anchors, rounded end sections and buffer end sections.

Concrete Median Barrier shall be measured by the linear foot in place. Measurement shall not include those portions of median barrier to be constructed as an integral part of sign foundations.

90.05 BASIS OF PAYMENT. Guard rail and median barrier rail will be paid for at the contract unit price, which price and payment shall be full compensation for the work.

The cost of end anchors, rounded end sections and buffer end sections shall be absorbed in the contract unit price for the rail.

Concrete Median Barrier shall be paid for at the contract unit price per linear foot for "Concrete Median Barrier," which price shall be full payment for furnishing and placing all materials, including dowel bars, shoes, pipe sleeves, reflector tabs, bolts and other similar items, and for all labor, tools, equipment, and incidentals necessary to complete the items, including the concrete median barrier tapered end sections, transition sections, and connections to existing median barriers where required.

SUBSECTION 90.40 GUIDE POSTS.

90.40 DESCRIPTION. "Guide Posts" shall consist of the furnishing and installation of various types of guide posts and accessories as stipulated in

the contract, meeting the requirements of the plans and specifications or as directed.

90.41 MATERIALS. Materials shall conform to the requirements of Article M-220.02.

90.42 CONSTRUCTION METHODS.

(A) Wood guide posts shall be installed in accordance with Article 90.03, the plans and as directed.

(B) Metal posts, when driven into the ground, shall be well protected to guard against damage. Damaged posts shall be repaired or replaced. The post shall be firmly set in the ground and within two degrees of plumb. When holes are dug the posts shall be firmly tamped into position. Locations shall be as shown on plans or as directed.

(C) Flexible guide posts shall be installed in accordance with the plans, special provisions and manufacturer's recommendations. When it is not desirable to dig a hole in the pavement, flexible guide posts may be mounted on a hard rubber base and nailed or epoxy cemented to the pavement.

90.43 METHOD OF MEASUREMENT. All types and kinds of guide posts shall be measured by the number installed and accepted.

90.44 BASIS OF PAYMENT. All types of guide posts, including accessories placed thereon, shall be paid for at the contract unit price, which price and payment shall be full compensation for the work.

SECTION 91

PAINTS AND PAINTING

91.01 GENERAL REQUIREMENTS. Paint shall consist of pigments of the specified composition ground to the required fineness in the specified vehicles, to which shall be added thinner and drier, as may be required in the specifications for each kind of paint. The paint shall not cake, liver, thicken, curdle, gel or settle quickly, shall be readily broken up with a paddle to a smooth uniformity of good brushing consistency, and shall dry to a uniform texture without streaking, running or saging when applied to a vertical surface.

When applied in a normal brushing coat under normal conditions of temperature and humidity, paint shall dry in not more than 24 hours, or as specified in Section M-280.

The painting of metal structures, post, poles, supports, and the like, shall include, unless otherwise provided, the proper preparation of the metal surfaces, the application, protection and drying of the paint coatings, the protection of pedestrians, vehicular or other traffic upon or underneath the bridge structure or other structures, the protection of all portions of the structure (superstructure and substructure) against disfigurement by spatters, splashes and smirches of paint or of paint materials, and the supplying of all tools, tackle, scaffolding, labor, workmanship and materials necessary for the entire work.

91.02 PACKING AND MARKING. Paint shall be delivered in such containers as ordered or specified. Each container shall bear a label with the following information shown: Name and address of the manufacturer, shipping point, trademark or trade name, kind of paint, formula, number of gallons, date and lot number. Each paint container shall be labeled in accordance with Montana labeling statutes.

91.03 SAMPLING AND TESTING. No paints shall be used prior to the receipt of an acceptance report from the Department of Highways laboratory.

Representative samples of paints or paint ingredients shall be taken at the point of delivery and submitted to the laboratory by the inspector.

Acceptance of paints or paint ingredients may be made by the DOH's laboratory on the basis of a certified formula submitted by the manufacturer. Representative samples of paint or paint ingredients will be taken

by the DOH's inspector at the point of delivery in conformance with the requirements of the DOH's Material Manual.

91.04 MATERIALS. Materials shall meet the requirements of Section M-280.

91.05 PREPARATION OF SURFACE. Rusted and galvanized metal surfaces to be painted shall be treated by brushing with a solution, meeting the requirements of Article M-280.02 (16). After drying 20 minutes the metal surface shall be rinsed with water. Painting shall be started within 24 hours.

All surfaces shall be thoroughly clean and dry prior to and during application of paint. Cleaning shall remove all rust, loose mill or welding scale, dirt, oil, or grease, and other foreign substances. Removal of rust, scale, and dirt shall be done with metal brushes, scrapers, chisels, hammers, sand blasting, flame cleaning, or other effective means. Flame cleaning will be permitted only when authorized by the engineer. Oil and grease shall be removed with clean petroleum solvents such as gasoline, cleaning naphtha or approved mineral spirits.

When blast cleaning is specified, on the plans or in the special provisions, it shall be accomplished by either the centrifugal wheel or the air blast method. The blast cleaning shall remove all mill scale and other substances down to the bare metal.

Special attention shall be given to the cleaning of corners and re-entrant angles. Before painting, all metallic shot and grit or sand shall be removed from the surfaces. The cleaning shall be approved by the engineer prior to painting.

Blast cleaning shall be performed with SAE No. S-330 shot or smaller, SAE No. G-25 grit or smaller, or dry sand passing through a No. 16 mesh screen U.S.-sieve series.

91.06 APPLICATION OF PAINT.

(A) General. No painting shall be done under what the engineer shall determine to be adverse weather conditions. The temperature of surfaces to be painted shall be approximately the same as the ambient air temperature. Each coat of paint shall be allowed to "dry through" prior to the application of a succeeding coat. The "dry through" condition shall be determined as set forth in paragraph (B)(4)(d) of this Article. Each primer and succeeding field coat of paint over metal shall have a minimum dry film thickness of 1.5 and 1.0 mil respectively.

(B) Painting Structural Steel Work.

(1) Application. All new structural steel work shall, unless otherwise especially provided in the plans or in the contract, be given three coats of paint. This shall also apply to other steel and metal structures such as bridge rail, guard rail, sign posts, structures for signs and the like that will be placed outside and exposed to the weather. The painting shall be done in a neat and workmanlike manner. Paint shall be applied in full coats, either with brushes or spray, so that every part of the surface is completely covered.

When paint is applied with brushes the paint shall be so manipulated under the brush as to procure a uniform, even coat in close contact with the metal or with previously applied paint. The primary movement of the brush shall describe a series of small circles to thoroughly fill all irregularities in the surface, after which the coating shall be brushed out and smoothed by a series of parallel strokes until the paint film has an even thickness. Brushes preferably shall be round or oval in shape, but if flat brushes are used they shall not exceed four inches in width.

If spraying equipment is employed, it shall be of a type that will insure a satisfactory application of the paint specified. When spraying is used, the pressure tank shall have an agitator to keep the paint thoroughly stirred.

The paint shall be thoroughly stirred previously by means of approved mechanical mixers before being removed from the containers, and the pigments shall be kept in suspension by stirring during the application. When the quantity of each coat of paint required is 5 gallons or less, the engineer may, at his discretion, approve hand mixing.

If it is necessary in cool weather to thin the paint in order that it may be spread more freely, such thinning shall be done only by heating in hot water or on steam radiators. The maximum temperature to which paint may be heated shall be 100° F unless otherwise specifically permitted by the manufacturer.

On all surfaces which are inaccessible for paint brushes, the paint shall be applied with spray or daubers especially constructed for the purpose.

Materials painted under cover in damp or cool weather shall remain under cover until dry or until weather conditions permit their exposure in the open.

The contractor shall be responsible for the satisfactory application of paint, and neither weather conditions nor the laboratory acceptance of materials used in the paint shall relieve him of the responsibility of obtaining a satisfactory paint job. If the painting is unsatisfactory, the paint shall be removed and the metal thoroughly cleaned and repainted. No addition-

al allowance will be made because of any expense incurred by these requirements.

(2) Shop Paint. All metal surfaces, except surfaces to be in contact after erection, shall receive one coat of red lead paint or basic Lead Silico—Chromate Primer meeting the requirements of Item (6) and (7), Article M-280.02, unless otherwise specified. The shop coat shall be applied immediately after fabrication, shop inspection and shop cleaning have been completed and the work has been accepted.

Metal surfaces to be in contact after erection shall not be painted unless otherwise provided for in the plans, Special Provisions, or as set forth in Article 91.06(C)(1) of these specifications. Material shall not be loaded for shipment until the paint is dry. Field coats shall not be applied in the fabrication shop except by written approval of the Construction Bureau.

Erection marks for the field identification of members shall be painted on painted surfaces. Erection marks, fabricators' names, and the like, shall not show through the final coat of paint due to build-up of film thickness. The paint used for stenciling must be a type that will not be harmful to either the shop coat or the first field coat.

With the exception of abutting chord and column splices and column and truss shoe bases, machine-finished surfaces shall be coated as soon as practicable after being accepted, and before removal from the shop, with a hot mixture of white lead and tallow. Surfaces of iron and steel castings machine-finished for the sole purpose of removing scales, scabs, fins, blisters and other surface deformations shall be given the shop coat of paint.

The composition used for coating machine-finished surfaces shall be mixed in the following proportions: four pounds tallow, two pounds white lead, and one quart linseed oil.

(3) Field Cleaning. When the erection work, including all riveting, straightening of all bent material, and the like, is complete, all adhering rust, scale, dirt, grease, unsatisfactory shop paint and other foreign matter shall be removed as specified under Article 91.05.

(4) Field Painting.

(a) Weather Conditions Affecting Surface. Paint shall not be applied when the ambient temperature is less than 40°F nor when there is a likelihood of a change in weather conditions within two hours after application which would result in an air temperature below 40°F or deposition of moisture in the form of rain, snow or condensation, etc. upon the surface. The engineer has the authority to enforce the requirement that no

paint be applied when impending weather conditions could result in damage to fresh paint. Paint shall not be applied when the relative humidity is greater than 85% nor when the combination of temperature and humidity conditions are such that moisture is condensing on the surface to be painted.

If temperatures and humidity are such that moisture is likely to condense on the surface, a small area thereon shall be moistened with a damp cloth so as to produce a clearly defined, thin film of water. If this film evaporates within 15 minutes, the surface shall be considered safe to paint from the standpoint of condensation at that time.

Paint shall not be applied to metal when surface temperatures are in excess of 110°F unless specifically permitted otherwise by the manufacturer of the paint in use. In no case shall paint be applied when surface temperatures are high enough to cause the paint to blister or to produce a porous paint film.

(b) Accessory Preparations and Spot Painting. Masonry and sole plates, the outside faces of end floor beams, the bottom of expansion devices, and all parts of steel work inaccessible for painting after erection, are to be thoroughly cleaned of all foreign matter, spot coated and painted the two field coats before erection. This painting shall be done on the site of erection and prior to the placement of the material to allow the paint to become thoroughly dry before assembling. Material so painted shall be in a position to require a minimum of handling after being painted, the handling to be done in such a manner as not to damage or abrade the painted surface. In case these painted surfaces are damaged during erection, they shall be properly repaired and repainted.

The exposed portion of guard angles for bridge decks, approach slabs, expansion devices and armored joints embedded in the roadway surface shall receive the shop coat of primer only. The entire curb or sidewalk portion of these members shall be given two coats of field paint as set forth elsewhere in this Article.

After erection and as soon as the field cleaning is done to the satisfaction of the engineer, the spot coat shall be applied to the edges of plates, rolled shapes and angles, to the heads of all field rivets, bolts, pins and nuts, and to all surfaces on which the shop coat has become damaged. In certain cases where a large portion of shop coat has become defective due to long periods of storage or due to the action of water, or other substance, the engineer may require a substantially complete reconditioning or replacement of the shop coat. Such painting shall be considered as spot coat work.

Small cracks and cavities which have not been sealed in a water-tight

manner by the first coat, shall be sealed with red lead paste before second field coat is applied.

(c) **Field Coating.** All metal, after the field cleaning has been completed and the spot coat has "dried through," shall be given two coats of field paint consisting of the first field coat meeting the requirements of Article M-280.02(6) or (7) and the second field coat consisting of aluminum paint meeting the requirements of Article M-280.02(3) unless otherwise provided in the contract. In no case shall a succeeding coat be applied until the previous coat has dried in compliance with the following requirements:

Prior to painting over a previously applied coat, the previous coat shall have attained a "dry through" condition. For field coat primers meeting the requirements of Article M-280.02 (6) and (7), this will require a minimum of 16 hours under ideal weather conditions. Under no circumstances shall a succeeding coat be applied in less than 16 hours.

(d) **Dry Through Testing.** The determination of the "dry through" condition shall be established by the following test: Press the thumb against the dried film with the free fingers resting against the panel. Exert moderate pressure against the surface and rotate the thumb through an angle of 90°. Examine the film for wrinkling, detachment or other evidence of distortion of the film which would indicate an inadequately cured condition. If no such distortion is evident, the paint is adequately cured for application of the succeeding coat.

This test shall be performed or witnessed by the engineer at such locations and frequencies as he determines necessary to reflect the true condition of the previous coat. Application of the succeeding coat will not be permitted without satisfactory compliance with the "dry through" test and the subsequent approval of the engineer to proceed with the work.

(e) **Painting Season.** Field painting of structural steel, metal posts or poles, bridge and guard rail shall not be started prior to May 1, nor shall it continue later than October 31 except on written permission.

(C) Painting Guard Rail.

(1) **Metal Rail, Guard and Bridge.** Metal rail units which are to be painted shall be painted in conformance with the requirements of Articles 91.05 and 91.06(A) and (B).

The following contact surfaces shall be painted the spot coat and the first and second field coats prior to erection and fit-up:

(a) Rail to post contact surfaces.

- (b) Bridge rail expansion sleeves.
- (c) Guard rail splice plates.
- (d) Bridge rail post base plates.
- (e) Overlapping ends of guard rail sections.

Full application of the first and second field coats shall be made after erection, fit-up and final adjustment of the rail to line and grade.

When galvanized members are specified, all abrasions to the posts, rail, bolts and nuts shall be repaired by painting with an approved zinc rich paint.

(2) Wood Rail and Posts. Wood posts and rail, when painted, shall receive one coat conforming to Article M-280.02(8) and two coats conforming to Article M-280.02(4). Application shall be in conformance with the requirements of Articles 91.06(A) and (B).

91.07 METHOD OF MEASUREMENT AND BASIS OF PAYMENT.

Paint and painting will not be measured separately or paid for directly, but shall be considered incidental and necessary to the work for which it is specified and shall be included in the payment of those items, unless specified otherwise.

SECTION 92

REMOVE, RESET AND ADJUST FACILITIES

92.01 DESCRIPTION. Remove, reset and adjust facilities shall consist of removing from an existing installation, storing and resetting such facilities and objects as designated by the contract. All work shall meet the requirements of the specifications, plans and special provisions or as directed. The work shall include the adjustment, to required lines and grade, of manholes, catch basins, inlets, water valve boxes and such other utility structures, shown on the plans or encountered in the work.

92.02 MATERIAL. All material such as concrete, brick and mortar shall meet the requirements of specifications noted in the section concerning the particular material involved. If the material is not covered in these specifications, the alternate material shall be equal, and comparable to that in the existing structure.

If substitution is necessary, prior approval shall be obtained.

If extensions for water valve boxes are required, they shall be comparable to the valve boxes found to exist. Close cooperation shall be maintained with the owner of each facility concerning material proposed to be used.

92.03 CONSTRUCTION METHODS. Facilities designated to be removed and reset shall be removed with utmost care and diligence with all efforts directed toward maintaining the existing condition of the facility. It shall be carefully handled, stored with care and reset when and where directed. The contractor shall be responsible for the condition and care of the facility from the time removal starts until resetting is completed, unless the engineer determines that such a provision is impracticable.

All existing manholes, catch basins, inlets, water valve boxes, gas and water shut-offs and other structures of this kind shall be adjusted to grade by either lowering or raising as required or in accordance with the details shown on the plans. Care shall be used in removing portions of the top of the manholes if the cover must be lowered so as not to damage the lower part of the manhole. Before the ring and cover are replaced, the top of the masonry on the manhole must be prepared to line and grade. Existing facilities and similar structures requiring adjustment, shall have the bar-

rel, box or supporting structure made solid by grouting, repairing or replacing as necessary. When completed, the adjusted facility shall be capable of supporting vehicle loads equivalent to those which occur within the traffic section of the roadway.

Water valve boxes must be excavated and exposed to readily determine if height adjustment can be made without the use of an extension.

Manholes, catch basins, inlets, water valve boxes and other similar structures shall be adjusted to temporary grade prior to the placement of Base Course material. Manholes shall be protected by planking or other suitable material until the new paving material has been placed around it. Before paving is started final adjustment of the structure shall be made to coincide with the grade of the new pavement. The cast iron ring and cover shall be replaced and set to proper grade after the pavement is in place.

Backfilling around structures shall meet the requirements of Section 77.

92.04 METHOD OF MEASUREMENT. Measurement will be made on the basis of each of the various types of structures required to be removed, reset or adjusted, completed and accepted as indicated by the contract and the description of the item.

92.05 BASIS OF PAYMENT. Payment shall be made in accordance with the contract unit price which price shall be full compensation for the work. The item description for "remove and reset," when listed in the contract, will be abbreviated to "reset."

"Adjust Existing Structures" will be paid for at the contract unit price, which price and payment shall be full compensation for the work.

Necessary excavation and backfill will not be measured or paid for separately, but will be considered to be incidental to and absorbed in the contract unit price for "Reset" or "Adjust Existing Structures."

SECTION 96

MARKERS AND MONUMENTS

96.01 DESCRIPTION. "Markers and Monuments" shall consist of the furnishing and erection of project markers, station markers, right-of-way monuments and other markers as may be specified, meeting the requirements of the plans and specifications, at the locations shown on the plans or as directed.

96.02 MATERIAL. Markers and monuments shall be constructed of material and in a manner meeting the requirements of the plans and standard drawings.

Concrete shall be Class "DD," meeting the requirements of Section 40. Reinforcing Steel shall meet the requirements of Section 47.

96.03 CONSTRUCTION METHODS. All markers and monuments shall be set out at the exact locations designated. They shall be thoroughly tamped into place with care taken to prevent shifting of position during the course of backfilling and tamping. Reference is made to the standard drawing.

Project markers shall be set three feet in the ground opposite the beginning and end of projects.

Station markers shall be, unless otherwise directed, set normal to the centerline, at the station shown on the marker, with the face of the marker furthest from the roadway, one foot inside the right-of-way line.

Right-of-way monuments, shall be set in such manner that the face of the monument furthest from the centerline will coincide with the right-of-way line.

96.04 METHOD OF MEASUREMENT. All markers and monuments will be measured by the number of each type used in the completed and accepted work.

96.05 BASIS OF PAYMENT. Markers and monuments will be paid for at the contract unit price for the number of each type, complete and accepted in place, which price and payment will be full compensation for the work.

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SECTION 97

NON-PARTICIPATING ITEMS

97.01 DESCRIPTION. This section shall concern work and materials not eligible for Federal Aid and materials that are stockpiled for use by the Montana Department of Highways.

97.02 MATERIAL. The material shall conform to the provisions of the particular section of these specifications which concerns the material specified, or as set forth in special provisions.

97.03 CONSTRUCTION AND PRODUCTION METHODS. These methods shall conform to the provisions of the particular section of these specifications which concerns the material specified in the contract, or as set forth in special provisions. Stockpile construction shall meet the requirements of Section 26.

97.04 METHOD OF MEASUREMENT. Measurements shall conform to the methods specified in the section of these specifications which concerns the material specified in the contract or as set forth in special provisions.

Haul of materials shall meet the requirements of the applicable provisions of Section 12, if such item is called for in the contract.

97.05 BASIS OF PAYMENT. Payment shall be made in accordance with the provision of the section of these specifications which concern the material specified in the contract, or as set forth in special provisions. Haul will be paid for as specified in Section twelve, if such item is called for in the contract.

SECTION M-100

AGGREGATES

M-100.01 AGGREGATE FOR CONCRETE.

These specifications cover the quality and size of fine and coarse aggregate for Portland cement concrete pavements or bases, highway bridges and incidental structures.

A. Fine Aggregate for Concrete

1. General Requirements

(a) Fine aggregate shall be minus 4 mesh material with a 5 percent allowable oversize and shall consist of natural sand having hard, strong, durable particles. Other approved inert material with similar characteristics, or combinations of the above materials may be used providing that all such materials meet the requirements of these specifications.

(b) Fine aggregate from different sources of supply shall not be mixed or stored in the same pile nor used alternately in the same class of construction or mix, without permission from the engineer.

(c) The requirements for deleterious substances and soundness given in (2) and (3) below will be waived in the case of aggregate for use in structures or portions of structures not exposed to the weather, or provided a satisfactory service record of at least five years' under similar conditions of service and exposure shall have been demonstrated.

2. Deleterious Substances

(a) The quality of deleterious substances shall be not greater than the following maximum limits.

	Recommended Limits % by Wt.	Maximum Limits % by Wt.
Coal and lightweight pieces.....	0.25	1.00
Clay lumps.....	0.50	1.00

(b) The material shall be reasonably free from other deleterious substances such as shale, alkali, mica, coated grains and soft, flaky particles.

3. Soundness

When the fine aggregate is subject to five cycles of the sodium

or magnesium sulfate soundness test, the total corrected percentage loss shall not exceed 10 or 15 percent by weight respectively.

4. Organic Impurities

Aggregates subjected to the colorimetric test for organic impurities and producing a color darker than the standard (AASHTO T-21, Alternate B) shall be rejected unless they pass the mortar strength test as specified in paragraph 5. Should the aggregate show a darker color than that of samples originally approved for the work, its use shall be withheld until tests satisfactory to the Engineer have been made to determine whether the increased color is indicative of an injurious quantity of deleterious substances.

5. Mortar-Making Properties

When subjected to the test for mortar-making properties, the fine aggregate shall develop a compressive strength at the age of 3 days, when using Type III cement, or at 7 days when using Type I or II cement, of not less than 90 percent of the strength developed by a mortar prepared with the same cement and in accordance with AASHTO T-71. Types I, II and III cement are described in the Standard Specifications for Portland Cement (AASHTO Designation M-85 or ASTM C-150).

6. Grading

(a) The gradation requirements given in part (b) below represent the extreme limits which shall determine suitability for use from all sources of supply. The gradation from any one source shall be reasonably uniform and not subject to change from the low to the high gradation limits specified in paragraph (b) below. The fineness modulus of representative samples taken from proposed sources shall be determined in accordance with AASHTO M-6. Fine aggregate from a source having a variation in fineness modules greater than 0.20 either way from the fineness modulus of the representative sample submitted may require a redesign of concrete mixes.

(b) Fine aggregate shall meet the following gradation requirements when tested by laboratory sieves and shall be graded from coarse to fine within those requirements.

Passing 3/8 inch sieve.....	100%
Passing 4 mesh sieve.....	95-100%
Passing 8 mesh sieve.....	65-95 %
Passing 16 mesh sieve.....	35-80 %
Passing 50 mesh sieve.....	5-30 %
Passing 100 mesh sieve.....	0-10 %
Passing 200 mesh sieve.....	0-3 %

(c) Fine aggregate shall have a fineness modulus of not less than 2.50 nor more than 3.10.

B. Coarse Aggregate for Concrete

1. General Requirements

(a) Coarse aggregate shall consist of crushed stone, gravel or blast-furnace slag, having hard, strong, durable pieces reasonably free from adherent coatings. Other approved inert materials with similar characteristics, or combinations of the above materials may be used providing that all materials meet the requirements of these specifications.

(b) The requirements for deleterious substance and soundness given in part (2) and (3) below will be waived in the case of aggregate for use in structures or portions of structures not exposed to the weather or provided a satisfactory service record of at least five years under similar conditions of service and exposure shall have been demonstrated.

2. Deleterious Substances

(a) The quantity of deleterious substances shall be no greater than the maximum limits.

	Recommended Limits % by Wt.	Maximum Limits % by Wt.
Coal and lignite.....	0.25	1.00
Clay lumps.....	0.25	0.25
Soft Fragments.....	2.00	5.00
Thin or elongated pieces having a length greater than 5 times av- erage thickness.....	0.00	15.00

(b) The material shall be reasonably free from other deleterious substances such as shale, alkali, mica coated particles and soft flaky particles.

3. Soundness

When the coarse aggregate is subjected to five cycles of the sodium or magnesium sulfate soundness test, the total percentage loss shall not exceed 12 or 18 percent by weight respectively.

4. Percentage of Wear

Coarse aggregate, when tested by the Los Angeles method, MT-209, shall have a percentage of wear not to exceed 40.

5. Slag for Concrete

Slag, when used in structural concrete, shall have a weight per cubic foot of not less 70 lb.
The 70 lb. value is considered the minimum safe limit for weight per cubic foot of slag for this type of construction. A higher weight per cubic foot should be required on all work where it is economically practicable to obtain materials conforming thereto.

6. Grading

Coarse aggregate shall be furnished in two separate sizes:

(a) Separation of material classes as 1½ inch shall be made at the three-quarter inch size. A tolerance of ten percent oversize is allowed on the 1½ inch and a five percent oversize is allowed on the three-quarter inch materials.

(b) Coarse aggregate shall be uniformly graded between the limits specified. The sizes designated shall meet the requirements of the following table, when tested by means of laboratory screens:

Designated Sizes	Percentage by Weight Passing Laboratory Sieves Having Square Openings							No. 4
	2	1 ½	1 ¼	1	¾	½	⅜	
No. 4 to ¾".....				100	85-95	40-75	20-55	0-10
No. 4 to 1½"....	100	95-100	70-95		35-70		10-30	0- 5
No. ¾ to 1½" ...	100	90-100	55-90	20-55	0-15			

(c) It is the intent of these specifications that there shall be a portion of the material above the minimum gradation shown in each designated size.

(d) The shape of aperture specified in determining compliance with specifications for size of coarse aggregate has no relation to the size and shape of the aperture or type of screen used in the production of the material.

The following test methods will be used to evaluate the quality of "aggregates for concrete" according to the previously stated requirements of Article M-100.01.

- Fineness Modulus of Fine Aggregate..... AASHTO M 6
- Sieve Analysis for Fine and Coarse Aggregate..... Mont. Test Method—M.T. 202
- Los Angeles Wear Test..... Mont. Test Method—M.T. 209
- Soundness (Sodium or Magnesium sulfate)..... AASHTO T 104

Mortar Making Properties.....	AASHTO	T	71
Organic Impurities.....	AASHTO	T	113
Coal and Light Particles.....	AASHTO	T	113
Clay Lumps.....	AASHTO	T	112

M-100.02 AGGREGATE FOR SURFACING.

Aggregate surfacing materials shall be free from injurious quantities of vegetable matter, balls of clay, frozen lumps or other extraneous matter and shall conform to the specifications as detailed in subsequent sections for the particular type and grading stipulated in the contract or shown on the plans.

Aggregate to be bituminized shall not contain deleterious substances in a quantity to exceed the following percentages by weight.

Clay lumps, shale and coal.....	1.5%
Soft particle.....	3.5%

The above percentages shall not be exceeded. No combination of shale, clay, coal or soft particles shall exceed 3.5 percent.

The contractor shall use reasonable care in the selection of material in a pit so a uniform product will be produced at all times. Unless otherwise specified, no compensation will be allowed for stripping of the pit required to secure satisfactory aggregate material.

M-100.03 SELECTED SURFACING. As determined by Montana Test Method M.T. 202, "Selected Surfacing" shall, for the grade specified, meet the requirements of that grade shown in the "Table of Gradations."

TABLE OF GRADATIONS

PERCENTAGE BY WEIGHTS PASSING SQUARE MESH SIEVES						
	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6
4 Inch Sieve	100%					
3 Inch Sieve		100%				
2½ Inch Sieve			100%			
2 Inch Sieve				100%		
1½ Inch Sieve					100%	
1 Inch Sieve						100%
No 200 Sieve not more than	15%	15%	15%	15%	15%	15%

There shall be added to this table, by implication herewith, a "special grade," the details for which shall be included in the contract by special provisions. The liquid amount for the material passing the No. 40 sieve shall not be in excess of 30; nor shall the plasticity index exceed six, as determined by Montana Test Method M.T. 208. Selected surfacing shall conform to other requirements that may be stipulated in the contract, which requirements may modify or amend these specifications, and which may be developed upon specific job conditions or source of material.

M-100.04 SAND SURFACING. As determined by Montana Test Method M.T. 202. "Sand Surfacing" shall, for the grade specified, meet the requirements of that grade in the table of gradations.

TABLE OF GRADATIONS

	PERCENTAGE BY WEIGHT PASSING SQUARE MESH SIEVES					
	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6
1½ Inch Sieve	100%					Special
1 Inch Sieve		100%				100%
¾ Inch Sieve			100%			.....
½ Inch Sieve				100%		.....
No. 4 Sieve					100%	.....
No. 10 Sieve						
Not less than	65%	65%	65%	50%	50%	50%
No. 200 Sieve						
Not more than	20%	20%	20%	20%	20%	10%

The liquid limit for the material passing the No. 40 sieve shall not be in excess of 25, nor shall the plasticity index exceed zero, as determined by Montana Test Method M.T. 208.

M-100.5 CRUSHED BASE COURSE TYPE "A"**TABLE OF GRADATIONS**

PERCENTAGE BY WEIGHT PASSING SQUARE MESH SIEVES						
	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6
4 Inch Sieve	100%					
3 Inch Sieve		100%				
2½ Inch Sieve			100%			
2 Inch Sieve				100%		
1½ Inch Sieve					100%	
1 Inch Sieve						100%
No. 4 Sieve	25-60% For All Grades					
No. 200 Sieve not more than	12% For All Grades					

(A) The liquid limit for that portion of the fine aggregate passing No. 40 sieve shall not exceed 25 nor shall the plasticity index exceed six as determined by Montana Test Method M.T. 208.

(B) Dust ratio limitations shall not apply to type "A" crushed base course unless specified in the special provisions.

(C) The wear requirement will not apply to crushed base course type "A".

(D) A tolerance of 5%, by weight, up to the next above specified gradation (5 inch for 4 inch max.) will be allowed.

(E) Binder, if required, shall meet the requirements of Article 20.02 (B).

M-100.06 CRUSHED BASE COURSE TYPE "B".**TABLE OF GRADATIONS**

PERCENTAGES BY WEIGHT PASSING SQUARE MESH SIEVES				
Passing	Grade 1	Grade 2	Grade 3	
2 Inch Sieve	100%			
1½ Inch Sieve		100%		
1 Inch Sieve	50-80%	.....	100%	
No. 4 Sieve	20-50%	25-55%	30-60%	
No. 10 Sieve	.....	.....	20-50%	
No. 200 Sieve not more than	8	8	8	

(A) The material, from which type "B" crushed base course is to be produced, shall have a wear factor not to exceed 60 percent at 500 revolutions as determined by Montana Test Method M.T. 209.

(B) Dust Ratio. The portion passing the No. 200 sieve shall not be greater than two-thirds of the portion passing the No. 40 sieve.

(C) Paragraphs (A), (D), and (E) of section M-100.05 will apply to crushed base surfacing type "B".

M-100.07 CRUSHED TOP SURFACING TYPE "A". The material, from which a type and grade is to be produced, shall have a wear factor not to exceed 50 percent at 500 revolutions, as determined by Montana Test Method M.T. 209.

TABLE OF GRADATIONS

PERCENTAGE BY WEIGHT PASSING SQUARE MESH SIEVES					
Passing	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
1 Inch Sieve	100%				
¾ Inch Sieve	.....	100%			
⅝ Inch Sieve	.....	.....	100%		
½ Inch Sieve	.....	.....	.....	100%	
⅜ Inch Sieve	.....	.....	.....	.....	100%
No. 4 Sieve	40-70%	40-70%	40-70%	40-70	50-80%
No. 10 Sieve	25-55%	25-55%	25-55%	25-60%	35-70%
No. 200 Sieve	2-10%	2-10%	2-10%	2-10	2-10%

The aggregate for all grades, including added binder or filler, shall meet the following supplemental requirements:

(1) Dust Ratio. The portion passing the No. 200 Sieve shall not be greater than two-thirds of the portion passing the No. 40 sieve.

(2) The liquid limit for that portion of the fine aggregate passing a No. 40 sieve shall not exceed 25 nor shall the plasticity index exceed six, as determined by Montana Test Method M.T. 208.

(3) The composite aggregate shall be free from adherent films of clay or other matter that will prevent thorough coating with bituminous material. It shall be of such nature that the coating of bituminous material will not slough off upon contact with water.

(4) Unless otherwise specified, when the aggregate is to be bituminized, both the material source and the composite aggregate shall not have a swell of more than ten percent in eight days and shall show no cracking or disintegration when tested for volume swell and water absorption by Montana Test Method M.T. 305.

(5) No intermediate sizes, for cover aggregate or for other purposes shall be removed from the material in the course of production, unless authorized, in writing.

M-100.08 CRUSHED TOP SURFACING TYPE "B".

TABLE OF GRADATIONS

PERCENTAGES BY WEIGHT PASSING SQUARE MESH SIEVES			
Passing	Grade 1	Grade 2	Grade 3
1½ Inch Sieve	100%		
1 Inch Sieve	.....	100%	
¾ Inch Sieve	.....	.....	100%
No. 4 Sieve	40-80%	40-80%	40-80%
No. 10 Sieve	25-60%	25-60%	26-60%
No. 200 Sieve	5-20%	5-20%	5-20%

The aggregate for all grades, including any added binder or filler, shall meet the following requirements:

(1) Dust Ratio. The portion passing the No. 200 sieve shall not be greater than two-thirds of the portion passing the No. 40 Sieve.

(2) The liquid limit for that portion of the fine aggregate passing a No. 4 sieve shall not exceed 35 while the plasticity index may vary from non-plastic to nine, as determined by Montana Test Method M.T. 208.

The material, from which Type "B" Crushed Top Surfacing is to be produced, shall have a wear factor not to exceed 50 percent at 500 revolutions, as determined by Montana Test Method M.T. 209.

M-100.09 CRUSHED COVER AGGREGATE — COVER MATERIAL.

TABLE OF GRADATIONS

PERCENTAGES BY WEIGHT PASSING SQUARE MESH SIEVES				
Passing	Grade 1	Grade 2	Grade 3	Grade 4
$\frac{3}{4}$ Inch Sieve	100%			
$\frac{5}{8}$ Inch Sieve	.....	100%		
$\frac{1}{2}$ Inch Sieve	.....	.....	100%	
$\frac{3}{8}$ Inch Sieve	.....	.....	.....	100%
No. 4 Sieve	40-70%	9-33%	9-50%	9-50%
No. 10 Sieve	25-55%	0- 8%	0- 8%	0- 8%
No. 200 Sieve	2-10%	0- 2%	0- 2%	0- 2%

As determined by Montana Test Method M.T. 202, the cover material shall meet the specified grading requirements of that grade in the table gradations for cover material.

M-100.10 CRUSHED COVER AGGREGATE — STONE CHIPS.

TABLE OF GRADATIONS

PERCENTAGES BY WEIGHT PASSING SQUARE MESH SIEVES			
Passing	Grade 1	Grade 2	Grade 3
$\frac{1}{2}$ Inch Sieve	100%		
$\frac{3}{8}$ Inch Sieve	.....	100%	
No. 4 Sieve	0-20%	0-20%	100%
No. 10 Sieve	0- 2%	0- 2%	0- 2%

When tested by Montana Test Method M.T. 202 in conjunction with a water wash, chips shall meet the specified grading requirements of that grading in the table of gradations for stone chips.

The material from which stone chips are produced shall have a wear factor not to exceed 50 percent at 500 revolutions as determined by Montana Test Method M.T. 209. The abrasion test shall be run using a 5,000 gram sample charge of material between the three-eighths inch and No. 4 sieves and an abrasive charge of eight balls.

M-100.11 BEDDING MATERIAL FOR STRUCTURES.

(A) **Description.** "Bedding Material" shall consist of a course and courses of granular material, placed for structure and particularly specified for certain types of culvert foundations and bedding meeting the requirements of the plans and specifications or as directed.

(B) **Material.** Bedding material shall be subject to approval. (a) It may be material commonly called "gravel." The material shall be uniformly graded, with a maximum size that will pass a four inch square opening and with at least 50% passing a No. 4 screen. The maximum size in the top three inches of the bedding material shall pass a 1½ inch square opening. (b) It may be material commonly called "sand." (c) It may be a combination of materials (a) and (b). The preferred material is "sand." See standard drawings. Regardless of the type of bedding material used, it shall be reasonably free of clay, silt or other unsuitable material. When bedding material is called for on the Standard Drawings, it shall conform to this section.

M-100.12 FILTER MATERIAL FOR STRUCTURES.

Backfill material for underdrains shall be termed and designated in the contract and on plans as "Filter Material." It shall be a granular material conforming in gradation to the following:

PERCENTAGE PASSING STANDARD A.S.T.M. SIEVE										
Filter										
Gradation	2	1 ½	1 ¼	1	¾	½	⅜	No. 4	8	16 50 100
No. 1							100	95-100	65-95	35-80 5-30 0-10
No. 2	100	95-100	70-95	35-70	10-30		0-5			

NOTES

SECTION M-120

BITUMINOUS MATERIALS

M-120.01 DESCRIPTION. This section sets forth the requirements for all types and grades of bituminous material for use in bituminous surfacing and allied purposes. All bituminous material used in the completed and accepted work shall meet the requirements for the particular type and grade stipulated in the contract.

M-120.02 MATERIAL. Bituminous materials shall conform to the following requirements except as they may be supplemented or modified:

- (a) Asphalt Cement shall conform to table MHD 30-M-20.
- (b) Rapid curing liquid asphalt (RC) shall conform to table MHD-62-1.
- (c) Medium curing liquid asphalt (MC) shall conform to table MHD-62-2.
- (d) Slow curing liquid asphalt (SC) shall conform to table MHD-62-3.

Emulsified Asphalt shall conform to tables MHD-69-1 and MHD-69-2 found at the end of this section.

Other bituminous materials of particular specification, which are not shown herein, may be developed upon requirement of the plans.

M-120.03 GENERAL REQUIREMENTS.

(A) Source. The source of bituminous material shall be approved by the engineer before shipments are made to any project and the source of supply shall not be changed after work is started, unless specifically permitted by the engineer in writing. The contractor shall not order delivery of bituminous material without approval of the engineer and the engineer will not be liable for the quantity shipped and delivered.

(B) Sampling. Samples of bituminous material shall be taken from shipments at the point of delivery on the project.

One quart sample in duplicate is to be drawn from each shipment at the direction of and under the supervision of the engineer.

One sample shall be immediately forwarded to the headquarters laboratory for testing, and the second sample shall be retained as a referee

sample in case of possible dispute. Before drawing samples into the sample container, enough bituminous material shall be drained off and discarded so as to completely flush and purge any previously contained materials from the lines, valves and fittings. In no case shall the quantity drained off be less than one gallon.

All transport vehicles shall be equipped with a spigot or gate valve furnished and installed in the unloading line, in the tanker at the centerline of the tank, in the pressure line from the unloading pump, or other location approved by the engineer. The spigot or gate valve shall have a diameter of not less than three-eighths inch nor more than three-quarters inch. The installation shall be at a location as free as possible from plant dust or any other possibility of contamination.

(C) Shipping. The supplier furnishing bituminous material shall carefully inspect each tank car or tank truck before it is loaded and ship only in clean, uncontaminated, fully insulated cars or trucks, sealed after loading by the supplier.

(D) Testing. Bituminous materials will be accepted on the basis of the results of tests made on samples selected and tested by the Department or its authorized representative.

The engineer may permit the use of bituminous materials before completion of all tests required, provided the results of tests for materials previously furnished by the refinery have been consistently satisfactory.

Permission for use of bituminous materials before completion of tests shall not be considered as a waiver of right to accept material in accordance with the following provisions:

When any test result is not within the specification limits without the application of any tolerance, the headquarters laboratory shall immediately notify the supplier and the engineer, who will then send in the retained sample for check testing.

In the event the retained sample tests satisfactorily, it shall be considered sufficient evidence that the material represented by the sample is satisfactory and acceptable. If the retained sample also fails to meet the requirements, the following schedule of tolerances may be applied to the specification requirements to determine whether the material may be accepted for use without a reduction in price. If any test results on the original sample fails the requirements but such results are within the established tolerances, the material may be accepted for use without a reduction in price.

If, however, the test results on both the original and retained samples are not within the tolerances, the average of the test values obtained by the Department Materials Bureau shall determine the basis for acceptance of the material with the following exception: Should any test result on either sample differ by more than the applicable ASTM Repeatability Unit, then the average of the test values shall not be used and that test result numerically nearest the specification requirement will be used as basis for acceptance of the materials.

In the event any material fails more than one test requirement, that requirement with the greatest violation shall determine the conditions for acceptance.

SCHEDULE OF TOLERANCES

FLASH TEST: Minus ten percent of the specification requirement for cut back asphalts and minus five percent of Asphalt Cements.

PENETRATION: Minus ten percent of the minimum specification limit, or plus ten percent of the maximum specification limit for liquid asphalt distillation residues and five percent of the specification limits for Asphalt Cements.

DISTILLATE: Percent of TOTAL DISTILLATE: Two milliliters may be added or subtracted at any distillation temperature before calculating the percent recovered.

PERCENT RESIDUE FROM DISTILLATION: Five percent of the specification limit.

DUCTILITY: Minus ten percent of the specification requirement.

SOLUBILITY IN CCl₄: Minus 0.5 percent.

VISCOSITY: Minus ten percent of the minimum specification requirement, or plus ten percent of the maximum specification requirement for cut back asphalts. Minus 25 percent of the minimum specification requirement and plus 25 percent of the maximum specification requirement for emulsified asphalt.

PERCENT RESIDUE OF 100 PENETRATION: Minus five percent of the specification requirement.

FLOAT TEST: Minus ten percent of the minimum specification requirement, or plus ten percent of the maximum specification requirement.

THIN FILM OVEN TEST: Plus ten percent of the maximum

specification requirement for percent loss in weight. Minus two percent to the minimum specification requirements for the percent retained penetration.

DEMULSIBILITY AND SIEVE TESTS: Minus ten percent of the minimum specification limit, or plus ten percent of the maximum specification limit.

HEPTANE-XYLENE EQUIVALENT: No tolerance shall be allowed, and materials in violation of specification shall be subject to the STANDARD PRICE REDUCTION.

WATER: No tolerance shall be allowed, and material in violation of the specification shall be subject to rejection, or 50 percent price reduction on the cost of the bituminous material, at the discretion of the engineer.

PARTICLE CHARGE: No tolerance will be allowed. Material in violation of this specification and any aggregate used in conjunction with its use shall be paid for at a unit rate not to exceed 50 percent of the cost of the materials.

(E) Acceptance. Suppliers of bituminous materials shall furnish a certificate of compliance, which document is to accompany the shipment and be presented to the engineer or his representative. This certificate, signed by a supplier's responsible representative, shall attest to the fact that the bituminous material complies with the Department's specifications for the type and grade of material represented and that the conveyance was inspected and found to be free of contaminating material. The certificate of compliance shall be the basis for tentative acceptance and use of the material.

One copy of the original bill-of-lading and one copy of the certificate of compliance shall be forwarded by the supplier to the engineer.

If any shipment of bituminous material fails to meet any one of the specification requirements after allowable tolerances have been applied, the material may be accepted by the engineer at a standard price reduction of 10 percent of the monetary value of the bituminous material. If any shipment fails to meet any of the specification requirements after twice the allowable tolerances have been applied, the standard price reduction shall be 25 percent of the monetary value of the bituminous material. If any shipment fails to meet any of the specification requirements after triple the allowable tolerances have been applied, the engineer may reject the material and require its removal from the work, or the engineer may accept the material at a price reduction of 50 percent of

the monetary value of the bituminous material. The monetary value of the bituminous material for the purpose of calculation of price reductions shall be the invoiced price to the contractor—f.o.b. the supplier (refinery).

Any bituminous material and aggregate removed from the work shall not be paid for and shall be replaced in kind at the expense of the contractor, which, when accepted, shall be paid for at the contract unit prices.

(F) Loading and Application Temperatures. Bituminous materials shall be applied at temperatures which will assure uniform mixing or spreading the temperatures will be designated by the engineer. Recommended application temperature ranges for the various kinds and grades of bituminous materials are listed in the following table. Bituminous materials shall not be reheated and loaded at temperatures exceeding the maximum application temperature unless expressly permitted.

Temperatures of mixtures produced in pug mills shall not be greater than necessary for hauling and placing and aggregate temperatures at the time of mixing shall be regulated accordingly. In no case shall the aggregate be introduced into a pug mill at a temperature of more than 25° above the temperature of the bituminous material.

The contractor or asphalt supplier shall furnish the engineer with data on the temperature-viscosity relationship of each asphalt to be used on the project. These data shall cover the range of temperatures and viscosities within which the asphalt may be used. On the basis of these data, the engineer will specify the temperature at which the material shall be used.

The specified temperature for mixing applications will be such that the asphalt viscosity is within the range of 150-300 centistokes (75-100 sec. Saybolt-Furol).

The specified temperature for spraying applications will be such that the asphalt viscosity is within the range of 50-200 centistokes (25-100 sec. Saybolt-Furol).

The following table contains recommended application temperature in fahrenheit degrees.

LIQUID ASPHALTS—RC, MC and SC

Pug Mill Mixing Temp. of
Aggregates for MC & SC
Liquid Asphalts, °F.

Loading Temp. °F.		Spraying Temp. °F.			
All Grades	Maximum*	Min.	Max.	Min.	Max.
70	195	105	185	90	155
250	245	140	225	125	200
800	275	175	265	160	225
3000	310	215	290	200	260

*Line Temperatures

ASPHALT CEMENTS

Grade All Penetration Grades Asphalt Cement	For Mixing		For Spraying	
	Minimum	Maximum	Minimum	Maximum
	As required to achieve viscosity of 150-300 centistokes (75-150 Sec- Saybolt-Furol)		350° Maximum	
Slow and Medium Setting	50°F	130°F	50°F	130°F
Rapid Setting	- - -	- - -	120°F	160°F

(G) Alternate Type or Grade of Bituminous Materials. The engineer reserves the right to change or substitute the type and grade of bituminous material to be used, depending on seasonal or other conditions; and in case of such change or substitution, a change order shall be executed prior to the use of the materials. The basis of payment for the changed or substituted bituminous material shall be the unit price for the respective type and grade of bituminous material called for in the contract, plus or minus the difference in cost to the contractor at the refinery between the type and grade called for in the contract and the changed or substituted type and grade with the exception that the grade of bituminous material, may be changed one step, by the engineer at no change in price.

M-120.04 METHOD OF MEASUREMENT. Bituminous material will be measured by the U.S. gallon or by the ton, as stipulated in the contract.

(A) If measured by the gallon, the volume shall be determined at a temperature of 60°F., or corrected to this basis by means of the appropriate group table as designated in volume correction tables, ASTM D-1250. Bituminous materials, when measured by the gallon, shall be transported in tanks previously certified as to their capacity and each tank shall be accompanied by its proper measuring rod and calibration card. Railroad tank cars shall have available inage and outage tables and dome capacity charts.

(B) When measured by the ton, the weight shall be determined on scales furnished by the supplier or on public scales most accessible to the source. Each vehicle used in transporting bituminous materials, other than railroad tank cars, shall be weighed completely empty and after loading and the difference in weights used as the basis for computing the tonnage. Any scale used shall be capable of weighing the transporting unit in an unbroken operation and shall be satisfactory to the engineer. The scales shall be tested and sealed, at the expense of the supplier, as often as the engineer may consider necessary to insure their accuracy.

In the case of plant mix operations the bituminous material may be weighed, if satisfactory to the engineer, by the plant scales.

If railroad tank cars are to be used in transporting bituminous materials, railroad-car weights will be accepted as the basis for computing the weight of bituminous material, provided that the loaded car is weighed over track scales. The stenciled tare on the car, unless proven to be erroneous, will be used in determining the net weight.

Full compensation for weighing bituminous material as specified shall be considered as included in the contract unit price per ton for the bituminous material and no additional compensation will be made therefore.

M-120.05 BASIS OF PAYMENT. Bituminous material used in the completed and accepted work, will be paid for at the contract unit price, which price and payment shall include all demurrage, storage, handling and other charges, all materials (including the bituminous material), tools, equipment, labor and performance of all work necessary or incidental to the furnishing, delivering, heating, hauling, manipulating and application of the bituminous material, unless otherwise expressly provided for.

The item description used in proposal forms will abbreviate "Penetration Asphalt Cement" "to Asphalt Cement"; e.g., "85-100 Penetration Asphalt Cement" will be listed as "85-100 Asphalt Cement."

TABLE 30-M-20

SPECIFICATIONS FOR ASPHALT CEMENT

	Penetration Grade									
	40-50		60-70		85-100		120-150		200-300	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Penetration at 25C (77F) 100 g, 5 sec.	40	50	60	70	85	100	120	150	200	300
Flash point, Cleveland Open Cup	450	...	450	...	450	...	425	...	350	...
Ductility at 25C (77F) 5 cm. per min., cm.	100	...	100	...	100	...	100	...	...	...
Solubility in trichloroethylene percent	99	...	99	...	99	...	99	...	99	...
Thin-film oven test, 1/8 in. (3.2 mm), 163C (325F) 5 hour .....	...	0.8	...	0.8	...	1.0	...	1.3	...	1.5
Loss on heating, percent	58	...	54	...	50	...	46	...	40	...
Penetration, of residue, percent of original Ductility of residue at 25C (77F) 5 cm. per min., cm. ....	...	...	50	...	75	...	100	...	100	...
Spot test: Heptane - xylene solvent, 35% xylene	Negative for all grades									

TABLE MHD-62-1 SPECIFICATIONS FOR RAPID CURING LIQUID ASPHALTS

	RC-70		RC-250		RC-800		RC-3000	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Kinematic Viscosity at 60 C (140F) (See Note 1) centistokes	70	140	250	500	800	1600	3000	6000
Flash point (Tab. open -cup). degrees C (F)	...	...	27 (80)	...	27 (80)	...	27 (80)	...
Water, percent	...	0.2	...	0.2	...	0.2	...	0.2
Distillation test								
Distillate, percentage by volume of total distillate to 360 C (680 F)								
to 190 C (374 F)	10	...	...	...	...	...	...	...
to 225 C (437 F)	50	...	35	...	15	...	...	...
to 260 C (500 F)	70	...	60	...	45	...	25	...
to 315 C (600 F)	85	...	80	...	75	...	70	...
Residue from distillation to 360 C (680 F) volume percentage of sample by difference	55	...	65	...	75	...	80	...
Tests on residue from distillation:								
Penetration, 100 g., 5 sec. at 25 C (77 F)	80	120	80	120	80	120	80	120
Ductility, 5 cm./min. at 25 C (77 F) cm	100	...	100	...	100	...	100	...
Solubility in Trichloroethylene, percent	99	...	99	...	99	...	99	...

Note 1. As an alternate, Saybolt-Furol viscosities may be specified as follows:

Grade RC-70—Furol viscosity at 50 C (122 F)—60 to 120 sec.

Grade RC-250—Furol viscosity at 60 C (140 F)—125 to 250 sec.

Grade RC-800—Furol viscosity at 82.2 C (180 F)—100 to 200 sec.

Grade RC-3000—Furol viscosity at 82.2 C (180 F)—300 to 600 sec.

TABLE MHD-62-2

SPECIFICATIONS FOR MEDIUM CURING LIQUID ASPHALTS

	MC-30		MC-70		MC-250		MC-800		MC-3000	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Kinematic Viscosity at 60 C (140 F) (See Note 1) centistokes	30	60	70	140	250	500	800	1600	3000	6000
Flash point (Tab. open-cup), degrees C (F)	38 (100)	...	38 (100)	...	66 (150)	...	66 (150)	...	66 (150)	...
Water percent	...	0.2	...	0.2	...	0.2	...	0.2	...	0.2
Distillation test:										
Distillate percentage by volume of total distillate to 360 C (680 F)	...	25	0	20	0	10	...	...	...	...
to 225 C (437 F)	40	70	20	60	15	55	0	35	0	15
to 260 C (500 F)	75	93	65	90	60	87	45	80	15	75
to 315 C (600 F)										
Residue from distillation to 360 C (680 F) Volume percentage of sample by difference	50	...	55	...	67	...	75	...	80	...
Tests on residue from distillation:										
Penetration, 100 g; 5 sec., at 25 C (77 F)	120	250	120	250	120	250	120	250	120	250
Ductility, 5 cm/cm., cm. (See Note 2)	100	...	100	...	100	...	100	...	100	...
Solubility in Trichloroethylene, percent	99	...	99	...	99	...	99	...	99	...

Spot test: Heptane - xylene solvent,
35% xylene

Negative for MC-3000 only.

Note 1. As an alternate, Saybolt Furol viscosities may be specified as follows:

Grade MC-70—Furol viscosity at 50C (122 F)—60 to 120 sec.

Grade MC-30—Furol viscosity at 25C (77 F)—75 to 150 sec.

Grade MC-250—Furol viscosity at 60C (140 F)—125 to 250 sec.

Grade MC-800—Furol viscosity at 82.2C (180 F)—100 to 200 sec.

Grade MC-3000—Furol viscosity at 82.2 C (180 F)—300 to 600 sec.

Note 2. If the ductility at 25C (77 F) is less than 100, the material will be acceptable if its ductility at 15.5C (60F) is more than 100.

TABLE MHD-62-3 SPECIFICATIONS FOR SLOW CURING LIQUID ASPHALTS

	SC-70		SC-250		SC-800		SC-3000	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Kinematic Viscosity at 60 C (140 F) (See Note 1) Centistokes	70	140	250	500	800	1600	3000	6000
Flash point (Cleveland open cup), degrees C (F)	66 (150)	...	79 (175)	...	93 (200)	...	107 (225)	...
Water percent	...	0.5	...	0.5	...	0.5	...	0.5
Asphalt residue of 100 pen., percent by wt.	50	...	60	...	70	...	80	...
Distillation test:								
Total distillate to 360 C (680 F), percent by volume	10	30	4	20	2	12	...	5
Tests on residue from distillation:								
Kinematic Viscosity at 60 C (140 F), Stokes	4	70	8	100	20	160	40	350
Ductility of 100 pen., residue at 25 C (77 F), 5 cm. per min., cm.	100	...	100	...	100	...	100	...
Solubility in Trichloroethylene,	99	...	99	...	99	...	99	...

Note 1: As an alternate, Saybolt-Furol viscosities may be specified as follows:

Grade SC-70—Furol viscosity at 50 C (122 F)—60 to 120 sec.

Grade SC-250—Furol viscosity at 60 C (140 F)—125 to 250 sec.

Grade SC-800—Furol viscosity at 82.2 C (180 F)—100 to 200 sec.

Grade SC-3000—Furol viscosity at 82.2 C (180 F)—300 to 600 sec.

TABLE MHD-69-1

SPECIFICATION FOR IONIC EMULSIFIED ASPHALT

Type	Rapid-Setting				Medium-Setting				Slow-Setting					
Grade	RS-1		RS-2		MS-1		MS-2		MS-2h		SS-1		SS-1h	
	min	max	min	max	min	max	min	max	min	max	min	max	min	max
Tests on emulsions:														
Viscosity, Saybolt Furol at 77 F (25 C)s	20	100	--	--	20	100	100	--	100	--	20	100	20	100
Viscosity, Saybolt Furol at 122 F (50 C)s	--	--	75	400	--	--	--	--	--	--	--	--	--	--
Demulsibility,* 35 ml, 0.02 N CaCl ₂ , percent	60	--	60	--	--	--	--	--	--	--	--	--	--	--
Residue by distillation, percent	55	--	63	--	55	--	65	--	65	--	57	--	57	--
Tests on Residue from Distillation Test:														
Penetration, 77 F (25 C), 100 g, 5 s	100	200	100	200	100	200	100	200	40	90	100	200	40	90
Ductility, 77 F (25 C), 5 cm/min, cm	40	--	40	--	40	--	40	--	40	--	40	--	40	--
Solubility in trichloroethylene, percent	97.5	--	97.5	--	97.5	--	97.5	--	97.5	--	97.5	--	97.5	--
Suggested uses	surface treatment, penetration macadam and tack coat	surface treatment and penetration macadam	plant or road mixture with coarse aggregate substantially all of which is retained on a No. 8 (2.36-mm) sieve and practically none of which passes a No. 200 (0.075-mm) sieve; tack coat										plant or road mixture with graded and fine aggregates, a substantial quantity of which passes a No. 8 (2.36-mm) sieve and a portion of which may pass a No. 200 (0.075-mm) sieve, slurry seal treatments	

* The demulsibility test shall be made within 30 days from date of shipment.

TABLE MHD-69-2

SPECIFICATIONS FOR CATIONIC EMULSIFIED ASPHALT

	Type									
	Rapid Setting		Medium Setting				Slow Setting			
	Grade		Grade		Grade		Grade		Grade	
	CRS-1	CRS-2	CMS-2	CMS-2h	CSS-1	CSS-1h				
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Tests on emulsions:										
Visc., Saybolt Furol at 77 F (25 C) sec. ....	..	..	..	..	..	..	20	100	20	100
Visc., Saybolt Furol at 122 F (50 C) sec.	20	100	100	400	50	450	..	..	..	..
Demulsibility 35 ^a ml 0.8% sodium dioctyl sulfo- succinate, %	40	..	..	..	..	..	..	..	..	..
Particle charge test	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive
Distillation:										
Oil distillate, by volume of emulsion, % .....	..	3	..	3	..	12	..	..	..	..
Residue, %	60	..	65	..	65	..	57	..	57	..
Tests on residue from dis- tillation test:										
Penetration, 25 C (77 F), 100 g, 5 sec.	100	250	100	250	100	250	40	90	100	250
Ductility, 25 C (77 F), 5 cm per min., cm.	40	..	40	..	40	..	40	..	40	..
Solubility in trichloro- ethylene, %	97.5	..	97.5	..	97.5	..	97.5	..	97.5	..
Suggested uses:	Surface treat- ment, pen- etration macadam and tack coat.	Surface treat- ment, pen- etration macadam.	Plant or road mixture with coarse aggregate substantially all of which is retained on a No. 8 sieve and practically none of which passes a No. 200 (0.075 mm) sieve.	Plant or road mixture with coarse aggregate substantially all of which is retained on a No. 8 sieve and practically none of which passes a No. 200 (0.075 mm) sieve.	Plant or road mixture with graded and fine aggregates, a substantial quantity of which passes a No. 8 sieve and a portion of which may pass a No. 200 (0.075 mm) sieve; slurry seal treatment.					

a The demulsibility test shall be made within 30 days from date of shipment.

b If the Particle Charge Test result is inconclusive, material having a maximum pH value of 6.7 will be acceptable.

SECTION M-150

JOINT MATERIALS

M-150.01 CONCRETE JOINT FILLERS.

(A) Concrete Pavement.

(1) **Expansion Joint Filler.** Expansion joint filler whenever called for on the plans shall be Type II cork and shall meet the requirements of AASHTO M-153.

(2) **Joint Sealing Material.** The sealing material for sealing all types of pavement joints shall be a hot poured thermo-plastic rubber or rubber asphalt compound meeting the requirements of AASHTO M-173, and shall be furnished in one grade only. Ready mixed cold applied joint fillers for sealing joints in concrete pavement will not be permitted except by prior written approval of the engineer.

The Department reserves the right to order discontinued the use of any joint filler which, in the opinion of the engineer, fails to produce a satisfactory joint under the methods employed by the contractor.

(B) **Concrete Structures Other Than Pavement.** Preformed expansion joint filler shall be type II cork and shall meet the requirements of AASHTO M-153.

(C) **Concrete Curbs, Gutters, Sidewalks.** Joint material shall comply with the requirements of AASHTO M-213.

M-150.02 CULVERT SEALERS.

(1) **Rubber Gaskets.** The ring gaskets shall meet the requirements of AASHTO M-198.

(2) **Flexible Plastic Gaskets.** Flexible plastic joint sealing compound shall have the properties set forth as follows: The sealing compound shall be produced from blends of refined hydro-carbon resins and plasticizing materials reinforced with inert mineral filler and shall contain no solvents. It shall not depend on oxidizing, evaporating or chemical action for adhesive or cohesive strength. It shall be supplied in extruded rope-form of such cross-section and size as to adequately fill spaces between pipe sections. It shall be protected by a suitable removable two-piece wrapper so designed as to permit removing one half, longitudinally, without disturbing the other. Its composition and properties shall conform to those set forth below.

		Minimum	Maximum
Bitumen (petroleum plastic content)	ASTM D 4	50	70
Ash-inert Mineral Matter	AASHTO T 111	30	50
Penetration	ASTM D 217 Cone		
32° F. (300 gm) 60 sec.		75 min.	—
77° F. (150 gm) 5 sec.		50 min.	120
115° F. (150 gm) 5 sec.		—	150 max.
Softening Point at 77° F. Min.	ASTM D 36	320° F. Min.	—
Specific Gravity at 77° F.	ASTM D 71	1.20	1.35
Weight per gallon		10.4	11.25
Ductility at 77 (cm) min.	ASTM D 113	5.0	—
Flash Point C.o.c., °F.	ASTM D 92	600	—
Fire Point C.o.c., °F.	ASTM D 92	625	—
Volatile Matter	ASTM D 6	—	2.0 max.

(3) **Joint Mortar.** Pipe joint mortar shall consist of one part portland cement and two parts approved sand with water as necessary to obtain the required consistency. Mortar shall be used within 30 minutes after its preparation.

Prepared sand-cement mixes, available commercially, will be permitted when approved by the laboratory.

M-150.03. SHEET COPPER, RUBBER OR PLASTIC WATER STOPS.

(1) **Sheet Copper.** Sheet copper, for waterstops, shall conform to the current specifications for copper sheet, strip, plate, and rolled for type ETP, ASTM designation: B-152. It shall have a nominal weight of 16 ounces per square foot within a tolerance of plus or minus 8 percent, unless otherwise designated on the plans or in the contract.

(2) **Rubber.** Rubber water stops may be molded or extruded and shall have a uniform cross section, free from porosity or other defects, conforming to the nominal dimensions shown on the plans. An equivalent standard shape may be furnished, if approved by the Engineer.

The water stop may be compounded from natural rubber, synthetic rubber, or a blend of the two, together with other compatible materials which will produce a finished water stop meeting the requirements tabulated herein. No reclaimed material shall be used. The Contractor shall furnish a certificate from the producer to show the general

composition of the material and values for the designated properties. The Contractor shall also furnish samples as ordered by the engineer.

Required properties and test methods—finished rubber water stop

Property	Federal test method standard No. 601	Requirement
Hardness (by shore durometer).	3021	60 to 70.
Compression set.....	3311	Maximum 30 percent.
Tensile strength.....	4111	Minimum 2,500 p.s.i. (17.24 MPa)
Elongation at breaking	4121	Minimum 450 percent.
Tensile stress at 300 percent elongation	4131	Minimum 900 p.s.i. (6.21 MPa)
Water absorption by weight	6631	Maximum 5 percent.
Tensile strength after aging.....	7111	Minimum 80 percent original.

(3) **Plastic.** Plastic water stops shall be fabricated with a uniform cross section, free from porosity or other defects, to the nominal dimensions shown on the plans. An equivalent standard shape may be furnished, if approved by the Engineer.

The material from which the water stop is fabricated shall be a homogeneous, elastomeric, plastic compound of basic polyvinyl chloride and other material which, after fabrication, will meet the requirements tabulated herein. No reclaimed material shall be used. The Contractor shall furnish a certificate from the producer, showing values for the designated properties in the following table. The Contractor shall furnish samples, in lengths adequate for making designated tests, as ordered by the Engineer.

Required properties and test methods — finished plastic water stop

Property	No. 406		ASTM equivalent	Requirement
	method standard	Federal test		
Tensile strength.....	1011		D638	Minimum 1,400 p.s.i. (9.65 MPa)
Elongation at breaking.....	1011		D638	Minimum 250 percent.
Hardness (shore).....	1082		D2240	60 to 75.
Specific gravity.....	5011			Maximum +0.02 from manufacturer's value.
Resistance to alkali.....	7011		D543	Maximum weight change: —0.10 percent to +0.25 percent.
(7 days using 10 percent NaOH) ..	.....		.....	Maximum hardness change +5 (shore); maximum tensile strength decrease: 15 percent.
Water absorption (48 hours)	7031		D570	Maximum 0.5 percent.
Cold bending.....	(¹)		(¹)	No cracking.
Volatile loss.....	6081		D1203	Not more than manufacturer's value.

¹The cold bend test will be made by subjecting a 1-inch (24.4 mm) by 6-inch (152.4 mm) by ⅜-inch (3.18 mm) strip of plastic water stop to a temperature of minus 20 degrees Fahrenheit (-29°C) for 2 hours. The strip will immediately thereafter be bent 180 degrees around a rod of ¼-inch (6.35 mm) diameter by applying sufficient force to hold the sample in intimate contact with the rod. The sample will then be examined for evidence of cracking. At least three individual samples from each lot will be tested and the result reported.

SECTION M-160

CONCRETE, CLAY, PLASTIC AND FIBER PIPE

M-160.10 NON-REINFORCED CONCRETE PIPE. This pipe shall conform to the requirements of AASHTO M-86 for the specified diameters and strength classes. Cement used in the manufacture of non-reinforced concrete pipe shall meet the requirements for Portland Cement. AASHTO M-85 (ASTM C-150).

M-160.11 REINFORCED CONCRETE PIPE.

(A) Reinforced concrete pipe shall meet the requirements of AASHTO M-170 (ASTM C-76), except as those requirements are herein supplemented or modified.

(B) Reinforced concrete pipe furnished under these specifications shall be produced by a manufacturing plant for which the method of manufacture and quality of product have been approved by the engineer prior to the date of award of contract.

(C) The equipment and methods for controlling the proportions for the concrete, forming and placing the reinforcement, the consolidation of the concrete in the molds, the protection and curing of the pipe, the molds, headers and pallets, shall be inspected and approved by the engineer prior to beginning fabrication.

(D) The use of elliptical reinforcement in circular pipe or round reinforcement in elliptical or arch pipe will not be permitted.

(E) Reinforced concrete arch culverts shall meet the strength requirements for Class A III concrete pipe as prescribed in ASTM C-506 or AASHTO M-206.

(F) Reinforced concrete elliptical culvert, storm drain and sewer pipe shall meet the requirements of ASTM C-507 (AASHTO M-207) for the specific diameters and strength classes.

(G) Type V cement shall be used where the foundation or backfill is alkaline, as designated by plans or special provisions.

(H) Flared-end terminal sections shall conform, as nearly as practicable within the limits of design, to Class III, AASHTO M-170.

(I) Cement used in the manufacture of reinforced concrete pipe shall meet the requirements for Portland Cement, AASHTO M-85 (ASTM C-150).

(J) The requirements of AASHTO M-170 par. 23(5) do not apply.

M-160.12 CONCRETE PRESSURE PIPE. This pipe shall conform to ASTM C-361 and applicable standard drawings. Pipes covered by this specification shall be for hydrostatic heads of 50, 75 and 100 feet, designated respectively as classes H50, H75 and H100.

M-160.13 PERFORATED CONCRETE PIPE. This pipe shall meet the requirements of AASHTO M-175 or ASTM C-444 for the specified diameters and strength classes.

The plans will show the class of perforated concrete pipe to be used. Class 1, standard strength; Class 2, extra strength. All non-reinforced.

M-160.14 POROUS CONCRETE PIPE. This pipe shall meet the requirements of AASHTO M-176 for the specified diameters.

M-160.15 VITRIFIED CLAY LINED REINFORCED CONCRETE PIPE. Designs for fully lined or half lined pipes of the specified strength classes shall be submitted by the manufacturer for approval. The applicable requirements of AASHTO M-170 and M-65 shall govern. Liner, or liner elements, shall be clay of first quality, sound, thoroughly and perfectly burned, without warps, cracks or other imperfections, and fully and smoothly salt glazed.

M-160.20 DRAIN TILE. This pipe shall meet the requirements of AASHTO M-178 or M-179 for the specified material, diameters and quality classes. When specified, the pipe spigot shall have integral spacer lugs to provide for an annular opening and self-centering feature.

The plans will show the class of drain tile to be used. Class 1, standard quality; Class 2, extra quality; Class 3, special quality or heavy duty.

M-160.21 CLAY PIPE. This pipe shall meet the requirements of AASHTO M-65, for pipe with full circular cross section, for the specified diameter and strength class. When specified the bell shall have integral spacer lugs to provide for an annular opening and self-centering feature.

The plans will show the class of clay pipe to be used. Class 1, standard strength; Class 2, extra strength; Class 3, standard strength perforated; Class 4, extra strength perforated; Class 5, cradle invert.

M-160.22 VITRIFIED CLAY PIPE. This pipe shall meet the requirements of AASHTO M-65 for the specified diameters and strength classes for circular unperforated pipe.

M-160.23 CRADLE INVERT CLAY PIPE. This pipe shall meet the applicable requirements of AASHTO M-65.

M-160.30 Asbestos-cement non-pressure sewer pipe shall meet the requirements of ASTM C 428.

Pipe furnished under these specifications shall correspond to, and be the same as, ASTM Classes 1500, 2400, 3300, 4000 and 5000.

M-160.31 Asbestos-cement pressure pipe shall meet the requirements of ASTM C-296.

Pipe furnished under these specifications shall correspond to, and be the same as ASTM Classes 100, 150 and 200.

M-160.32 PERFORATED ASBESTOS CEMENT PIPE. This pipe shall meet the requirements of AASHTO M-189 for the specified diameters.

The name will be abbreviated to "Asbestos Drain Pipe" when used in plans and the contract.

M-160.40 BITUMINIZED FIBER PIPE. This pipe shall meet the requirements of AASHTO M-158, ASTM D-1861 or D-1862.

M-160.41 PERFORATED BITUMINIZED FIBER PIPE. This pipe shall meet the requirements of AASHTO M-177 for the specified diameters. Unless otherwise specified, either Type I or Type II couplings may be furnished.

M-160.50. POLY (VINYL CHLORIDE) (PVC) SEWER PIPE AND DRAIN PIPE. This pipe shall conform to the requirements of ASTM D 2729, except wall thickness shall conform to ASTM D 2836, Table 3. For perforated pipe, the size and spacing of perforations shall conform to AASHTO M-189, (ASTM C 508.) Other types of plastic pipe may be substituted in lieu of PVC. However, written permission to substitute must be obtained from the engineer prior to installation.

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SECTION M-170

METAL PIPE

M-170.01 CAST IRON PIPE.

(A) Cast iron culvert pipe shall meet the requirements of AASHTO M-64 or ASTM A-142 for the specified diameters and strength classes. Unless otherwise specified either smooth, corrugated or ribbed pipe may be furnished. Pipe of diameter in excess of 48 inches shall conform to the U.S.A.S.T. Standard for cast iron pit cast pipe for the specified diameter and strength class.

Cast iron culvert pipe is available in three weights: standard, heavy and extra-heavy. The weight to be used will be specified on the plans.

(B) Cast iron soil pipe shall conform to commercial standard (U.S. Dept. of Commerce) No. CS188. Pipe furnished under this specification shall be coated in accordance with CS188.

Soil pipe is available in two weights: extra-heavy (Exhvy) and service weight (Serwt). Fittings shall conform to CS188.

(C) **Cast iron pressure pipe.** Cast iron pressure pipe shall conform to ASTM A-377 or ANSI specifications A21.2, A21.3, A21.6, A21.7, A21.8, A21.9. ANSI A21.3, A21.7 and A21.9 are designed primarily for transmission of gas. The others are for transmission of water and other liquids.

Outside and inside coating shall be bituminous material. If cement mortar lining is required it shall be so specified and shall conform to ANSI A21.4.

When a particular type of method of casting is desired — (a) pit cast (A21.2); (b) centrifugally cast in metal molds (A21.6); (c) centrifugally cast in sand-lined molds (A21.8) — it shall be so specified. When no type is specified, any one of the three types will be acceptable, if meeting requirements.

When a certain class of pipe is specified, under A21.6 and A21.8, the term shall denote working pressure in lbs/sq. in., e.g., class 50, class 150, class 350.

Pipe will be furnished with bell and spigot joints unless mechanical joints are specified.

Push-on joints, especially designed for use with a special rubber gasket, will be acceptable. The rubber gasket shall conform to ASTM C-443.

(D) Joints and Fittings. Joints and fittings shall conform as closely as practicable, with commercial practice, to the materials used in the pipe itself.

(E) Jointing Materials. Yarn for use in joints shall be dry, braided and sterilized jute of the best quality available or a substitute recommended by the pipe manufacturer and approved by the laboratory. A packing consisting of a braided jacket and having a jute core may be used in lieu of jute packing. Lead shall be pig lead containing not less than 99 percent pure lead.

Jointing materials for pipe culverts, unless otherwise specified, shall be recommended by or provided by the supplier.

M-170.02 CORRUGATED STEEL PIPE AND PIPE ARCHES. These pipes and coupling bands shall meet the requirements of AASHTO M-36 and AASHTO M-218 for the specified sectional dimensions with the following modifications.

Connecting bands for irrigation and syphon pipes shall be at least 24 inches wide. The portion of the pipe that will be covered by the connecting band shall be welded or riveted with flush type rivet heads unless formed with helical corrugations.

Pipe with helical corrugations shall have a continuous seam extending from end to end of each length of pipe section. Helical seams shall be fabricated in a manner that they will develop the full strength of the pipe and not affect shape or nominal diameter of the pipe. Folded lock seams or ultra-high frequency resistance butt-welded seams shall be used. Folded lock seams shall be formed with sufficient pressure to prevent seam slippage which would appreciably affect the load carrying capacity of the pipe without damaging the metal to such an extent that a plane of weakness is created. The metal used in fabricating lock seams shall be one that will permit cold forming without damage. Welded seams shall be controlled so the combined width of the weld and adjacent spelter coating burned by welding does not exceed three times the metal thickness. If the spelter is damaged by the welding outside the above specified area, the weld and damaged spelter adjacent to the weld shall be cleaned and painted as specified in AASHTO M-36.

M-170.03 BITUMINOUS COATED CORRUGATED STEEL PIPE AND PIPE ARCHES. These pipes and the coupling bands, unless otherwise specified, shall meet the requirements of AASHTO M-190 for the specified type of bituminous coating. Coupling bands shall be fully coated with

bituminous material. Shop-formed elliptical pipe and shop-strutted pipe shall be furnished where specified.

Special sections, such as elbows, shall be of the same gage as the pipes to which they are joined and shall conform to the applicable requirements of AASHTO M-190. Coating and invert paving shall be of the type specified.

When asbestos bonded bituminous coating is specified, these requirements shall equally apply and in addition the special process of embedding asbestos fiber in the molten metallic bonding medium shall be used to bond the bituminous coating.

(A) Basis Structure. The metal pipe culverts and retaining walls to be treated as prescribed in this section, shall conform to the applicable specifications or special provisions.

(B) Bituminous Material. (1) Pipe culverts and other facilities which will be assembled at a factory or central plant shall be coated with material and in accordance with AASHTO M-190.

(2) All structural plate pipe culverts, retaining walls and other facilities which must be protected by an application of bituminous material and which will be assembled at the construction site shall be treated with a bituminous-fibrous product which will pass the test requirements set forth in paragraph (E). The fibrous material shall be a combination of long fibre asbestos and carefully selected durable finely divided mineral fillers. This shall be designated type D—Bituminized, regardless of the methods described under paragraph (D). The fibrous material shall pass the tests set forth in paragraph (E).

(C) Asbestos-Bonded. The galvanizing or spelter coating shall meet the requirements of the provisions of AASHTO M-36. It shall be applied at such a rate per square foot, that, when sampled in accordance with specified methods, the recoverable amount of spelter, after the asbestos-bond has been removed, shall be not less than 1.5 ounces per square foot of double exposed surface. Asbestos-bonded metal pipe culverts shall be fabricated from asbestos-bonded sheets, the base metal of which shall meet the requirements of Section M-170.02 or Section M-170.04. Both sides of the metal sheets shall be coated with a layer of asbestos fibers applied by pressing a sheet of asbestos fibre into the molten metallic bonding medium. Immediately after the metallic bond has solidified, the asbestos fibers shall be thoroughly impregnated with a bituminous saturant. The finished sheets shall be of first-class commercial quality, free from blisters and uncoated spots. After the asbestos-bonded sheets have been fabricated into culvert sections, the bituminous coating shall be

applied in accordance with paragraph (D). This type of treatment will be designated as Type E— Asbestos-Bond.

(D) Application.

(1) Application and testing of bituminous material for Types A, B and C bituminizing shall meet the requirements of AASHTO M-190.

(2) Type D bituminizing shall be performed after assembly of the basic structure, in whole or in part. The facility shall be treated with a bituminous-fibrous product, as described in paragraph (B) (2) to a minimum thickness of 0.05 inch, over the entire outside and on the entire bottom one-third of the inside circumference. Arch types shall be coated inside to the top of the corner radius. Measurement of thickness shall be made on the crest of corrugations. This also shall apply to the back or fill side of corrugated metal retaining walls.

The surface of the facility shall be thoroughly clean and dry, when the bituminous-fibrous material is applied. Air temperature at time of bituminizing must be at or above 50° F. and rising. If the temperature is 70° F. or higher, it need not be rising. The supplier or contractor may perform the bituminizing in any manner but the finished product must meet the test prescribed in paragraph (E) and be approved.

(E) Sampling and Test Requirements — Type D.

(1) **Sampling.** All tests of bituminizing material shall be made on samples obtained from the vat or container immediately before application of the material. One or more 5 oz. samples shall be obtained and submitted to the engineer. Bituminous-fibrous material shall pass the tests set forth in parts (B), (C), (D) and (E) of this article.

(2) **Shock Test.** Shall meet the requirements of AASHTO M-190.

(3) **Flow Test.** Spray and condition a coating of the material, as described in part (B), with parallel lines spaced 1/2 inch apart scored across the width of the surfaces. The panel shall be suspended in a vertical position, with the lines horizontal, in an oven at 320° F. - 330° F. for 24 hours. Remove the panel and observe the surface of the coating for shifting or sagging of the lines. Shifting or sagging of the lines shall be cause for rejection of the material.

(4) **Acid and Alkalai Resitance Test.** A coating of the material, prepared as described in AASHTO M-190 shall show no signs or evidence of attack or deterioration when immersed for 24 hours in a 10 percent solution of hydrochloric acid, sulphuric acid or sodium hydroxide. On

removal of the coating by solvent cleaning, the panel surface must be free of any pitting, rusting or other damage caused by the test.

(5) Water Vapor Permeability Test. The water vapor permeability of 1/8 inch wet thickness shall be not over 0.0005 oz. (0.66 grains) per square foot per 24 hours under vapor pressure differential of 11.8 mm. of mercury at 22° C.

M-170.04 CORRUGATED STEEL PIPE FOR UNDERDRAINS. This pipe shall conform to the requirements of Montana Test Method M.T. 402 for classes.

When galvanized metal pipe culverts are required to be asbestos bonded, bituminous coated or provided with a paved invert, such work and material shall meet the requirements of Article M-170.03.

The plans will show the size of under drain to be used. Materials shall conform to AASHTO M-36. The class of drain shall be the option of the contractor unless the class is shown on the plans.

Semicircular Underdrain. The underdrain shall be formed by semi-circular pipe with a top shield of corrugated metal. See Standard Drawings. Materials shall conform to AASHTO M-36 or Montana Test Method M.T. 402 for sheet metal parts. Nuts, screws, caps and similar parts shall be galvanized to meet the requirements of ASTM A 153.

Metal subdrain shall consist of an unperforated semicircular pipe of 18 gage metal with a top shield of 18 gage corrugated metal. The semi-circular pipe shall be approximately 4 5/8 inches in diameter and shall have a 1 1/4 inch continuous lip extending outwardly along each side. The top shield shall be not less than 7 3/4 inches wide, shall have corrugations approximately 7/8 inch center to center and approximately 5/16 inch in depth. They shall be secured to the lip of the pipe by integral clips or rivets spaced at about 3 1/2 inches center to center and as necessary to insure rigid construction. Coupling bands shall be shaped to fit and of adequate length to provide a secure connection.

Screens and Caps. Screens of 2 x 2 mesh No. 17-19 wire cloth (approximately 1/2 inch by 1/2 inch openings) shall be securely fastened over the outlets of all underdrains by means of galvanized wire. Screens shall be galvanized after weaving but prior to cutting. Suitable caps fabricated of the same base metal and gage as used in the pipe shall be affixed to securely close the dead end of each subdrain.

When bituminizing is specified by the plans or special provisions, it shall conform to type A as covered by Article 170.03, part (B) (1). Nuts, bolts and screens will not be coated.

Perforated corrugated steel underdrains shall meet the requirements of AASHTO M-36.

M-170.05 CORRUGATED ALUMINUM PIPE AND PIPE ARCH CULVERTS. Corrugated aluminum pipe and pipe arch culverts shall meet the requirements of Montana Test Method M.T. 401 except that full circle pipe may be formed into standard pipe-arch when required.

M-170.06 CORRUGATED ALUMINUM PIPE FOR UNDERDRAINS. This pipe shall meet the requirements of AASHTO M-197.

M-170.07 SEAMLESS STEEL PIPE. Steel pipe shall meet the requirements of ASTM A 120. Seamless only will be designated.

M-170.08 COPPER PIPE. Copper tube or pipe shall meet the requirements of ASTM B-88.

M-170.09 Vacant.

M-170.10 SLOTTED CORRUGATED STEEL PIPE. This pipe shall be commercially fabricated and of the slot type with the grate and corrugated steel pipe an integral unit. The grate spacer bars shall be pressure or fusion welded to the bearing bar. All grating materials shall meet the requirements of ASTM A-36 and shall be galvanized after fabrication.

SECTION M-210

FENCING MATERIALS

M-210.01 CHAIN LINK FENCE.

(A) **General.** All material used in the construction shall meet the requirements of AASHTO M-181. The fence fabric shall be type 1—Zinc-Coated Steel, type 2—Aluminum-Coated Steel, type 3—Aluminum Alloy, as set forth in the contract.

Posts, rails, gate frames, expansion sleeves, wire ties, fabric ties, hog rings, tension wire, miscellaneous fittings and hardware furnished for use in conjunction with type 1 or type 2 fabric shall be of zinc-coated steel and those furnished for use in conjunction with type 3 fabric shall be of aluminum alloy.

(B) Posts.

(1) **Steel.** Line posts for five and six foot fence shall be 2 inch x 2 1/4 inch "H" column with nominal weight of 4.1 pounds per linear foot, three and four foot fence shall be 1 5/8 inch x 1 7/8 inch "H" column with nominal weight of 2.80 lbs. per linear foot. Gate posts shall be 3 1/2 inches nominal diameter pipe with nominal weight of 9.1 pounds per linear foot. End, corner and "pull" posts (braced line posts) for five and six foot shall be 2 1/2 inches-nominal diameter pipe with nominal weight of 5.79 pounds per linear foot; for three and four foot fence shall be 2 inches nominal diameter with a nominal weight of 3.65 pounds per linear foot. All posts shall be fitted with an approved top so designed as to fit securely over the post and carry the top rail or cable. The base of the top fitting shall carry an apron around the outside of the post. Length of post will be as shown on standard drawings.

(2) **Aluminum.** All posts shall conform to ANSI schedule 40 with plain ends. Line post shall be 2 inch diameter; end and corner posts 2 1/2 inch diameter; gate posts shall conform to sizes shown in the following table:

ANSI Nominal Pipe Sizes Inches	Swing Gate Openings— Feet	
	Single Gate	Double Gate
2 1/2	Up thru 6	Up thru 12
3 1/2	7 thru 13	13 thru 26
6	14 thru 18	27 thru 36

Lengths shall be as shown on the standard drawing. Post tops shall be supplied for each post and be designed to carry the top rail or cable.

(C) Cable.

Top tension cable shall be 3/8 inch diameter Aluminum-Coated 7-strand steel cable conforming to ASTM A-474, common grade. Minimum weight of Aluminum coating shall be 1.2 oz. per sq. ft. of uncoated wire surface.

(D) Cable Attachments. Shoulder eye bolts shall be 5/8 inch diameter and of sufficient length to fasten to the type of posts used. Turnbuckles shall be of the shackle end type, 1/2 inch diameter, with standard takeup of 6 inches and provided with 3/8 inch diameter pins. Thimbles shall be light weight wire rope thimbles for use with 3/8 inch diameter cable. Wire rope clips shall have a U-bolt diameter of 7/16 inch for use with 3/8 inch diameter cable. Anchor shackles shall be 3/8 inch diameter with a minimum distance between eyes of 11/16 inch and a pin diameter of 7/16 inch. Sizing shall be gage 26 galvanized annealed iron wire.

(E) Braces and Truss Rods.

(1) Steel. Compression braces shall be pipe 1 1/4 inch nominal diameter, nominal weight 2.27 pounds per linear foot, or 1 1/2 inch x 15/16 inch "H" column, nominal weight 2.0 pounds per linear foot. Tension truss rods shall be 3/8 inch round rods with drop forged turnbuckles, or other approved type of adjustment.

(2) Aluminum. Compression braces shall conform to ANSI schedule 40 pipe with plain ends and shall be 1-1/4 inch in diameter. Aluminum truss or diagonal brace rods shall be a minimum of 3/8 inch in diameter.

(F) Fence Fabric.

(1) Steel. The fabric shall consist of gage 11 wire for three and four

foot fences and gage 9 wire for five and six foot fences. It shall be woven into approximately 2-inch diamond mesh.

The width of the fabric shall be as specified or shown on current standard drawings. Chain link fabric shall be finished at top and bottom as shown on the standard drawing, with a "twisted and barbed" selvage. Barbing shall be done by cutting the wire on the bias.

(2) **Aluminum.** The fence fabric shall be wound and interwoven from gage 11 wire for three and four foot fences and gage 9 wire for five and six foot fences. The pickets shall form a continuous chain link fabric having 2 inch mesh. Top and bottom selvage shall be twisted and barbed.

(G) Fabric Bands and Stretcher Bars.

(1) **Steel.** Fabric bands shall not be less than 1/8 inch x 3/4 inch in sections and stretcher bars not less than 1/4 inch x 3/4 inch in sections.

(2) **Aluminum.** 1/4 inch x 3/4 inch flat stretcher bars with square edges shall be used on three and four foot fences; 1/4 inch x 1 inch bars on five and six foot fence. Flat band fabric ties shall be about 1/2 inch wide by 0.060 inch thick.

(H) Tie Wire.

(1) **Steel.** Tie wire for steel fence shall be gage 9 iron wire. Hog ring fasteners shall be gage 11.

(2) **Aluminum.** The wire shall be approximately gage 9. Hog ring fasteners shall be 0.110 inches in diameter.

(I) Tension Wire.

(1) **Steel.** Tension wire shall be gage 7.

(2) **Aluminum.** Tension wire shall be approximately gage 6.

(J) Gates.

(1) **Steel.** Gate frames shall be constructed of pipe of sizes and weights shown below. The corners of the gate frame shall be fastened together and reinforced with a malleable iron fitting designed for the purpose, or they may be welded. Welding shall conform to Article 43.06 (H).

Single Gate frame, 6 ft. and 8 ft. wide — 1 1/4 in. nom. dia. 2.27 lbs./ft.

Single Gate frame, over 8 ft. wide—1 1/2 in. nom. dia. 2.72 lbs/ft.

Cross trussing shall be three-eighths inch galvanized iron adjustable rods.

Chain link fence fabric for filling the gate frame shall meet the requirements specified in part (G) of this article.

Each gate shall be furnished complete with necessary hinges, latch, and drop bar locking device designed for the type of gate posts and gate used on the project.

Gates with frames constructed of steel sections, other than the pipe specified above and fabricated in such a manner as to form a gate of equal or better rigidity, may be used provided they are approved by the engineer.

(2) Aluminum. Gate frames shall be fabricated from 1 1/2 inch ANSI schedule 40 pipe, assembled by welding in accordance with the requirements of Article 43.06 (H). Hinges shall conform to above for fittings. Locking devices may be galvanized malleable iron or steel; plunger bars may be tubular or bar steel.

Gates sizes shall be as specified with the height conforming to the height of fence. Other general provisions prescribed for steel gates shall apply to aluminum gates.

M-210.02 WIRE FENCE AND FARM FENCE.

(A) General. When the contract or plans specify a new fence, then all materials must be new and unused. When an existing fence is to be moved and/or reset, materials therefrom may be reused if acceptable to the engineer; any new materials anticipated to be required will be listed as bid items in the contract. When the contract specifies the relocation of a fence, then any needed materials shall be new and of quality and type as near that of the old fence as is practicable. Any galvanized or galvanealed materials which bear serious abrasion or broken coating shall be rejected. See Article 81.05 for additional provisions. All posts for new fences shall be wood unless the special provisions specify otherwise. All galvanizing or galvanealing shall be class I or heavier.

When the contract calls for and lists items for new posts, new barbed wire or new woven wire, it applies only in those cases where an existing fence is being moved and reset. The item does not apply to materials for a new fence. When such items are in the contract, they shall conform to the following: A spool of barbed wire is 80 rods; a roll of woven wire is 20 rods. The price for any of these items shall include

installation. Type F-2, F-3, F-4, F-5, and F-6 farm fence, and the attendant panels and gates, shall be constructed of new materials with the exception that deadmen may conform to part (K) below.

(B) Woven Wire. Woven wire shall conform to ASTM A-116 requirements. Mesh design shall be Design Number 832-6-12 1/2 as shown in Table II of the appendix. Fabric coating shall conform to Table I, Class I. The mesh design for farm fence shall be as specified or of height and mesh equal to the fence being moved.

(C) Barbed Wire. Barbed wire for wire fence shall conform to ASTM A-121, Class 1 coating, and shall consist of two strands of gage 12 1/2 wire, twisted, with two-point gage 14 barbs of round wire and spaced not more than four inches apart.

(D) Brace Wire. Brace wire shall be gage 9, soft. It will be used for constructing braces and panels, tying to anchors, etc.

(E) Staples and Nails. Wire staples of the barbed U-shaped type shall be used to fasten the wire fencing to the wooden posts and shall be not less than 9 gauge, 1-3/4 inches long. Nails shall be of the size approved by the engineer.

(F) Tie Wires. Tie wires shall be not lighter than gage 12 1/2. Used for fastening barbed and woven wire to metal posts. Commercial fasteners, supplied with the wire, may be used when approved. All shall be galvanized.

(G) Metal Fence Stays. These shall be of standard make, made from wire base, gage 9 1/2, twisted to form a 2-wire unit. Galvanizing shall be class 1.

(H) Metal Posts and Braces. Posts, braces and anchor plates for "Wire Fence" may be galvanized or painted. Galvanizing shall be in accordance with AASHTO M-111 (ASTM A-123). Painting shall be in accordance with good manufacturing practice. Nuts, bolts, fittings and other hardware shall be galvanized in accordance with ASTM A-153.

All post and braces for farm fence shall be painted in accordance with good manufacturing practice.

Fence posts and braces shall be of the lengths set forth in table A-post lengths.

Table A — Post Lengths

Fence	Post Type	Corner, End, Gate, Pull & Panel Posts	Line Posts	Brace and Brace Rail
Wire	Metal	7'8"	6'6"	7'8"
Wire	Wood	8'0"	7'0"	8'0"
Farm	Metal	7'0"	6'6"	7'8"
Farm	Wood	8'0"	7'0"	8'0"

Metal fence posts shall be the dimensions shown in Table B.

TABLE B

Fence Type	Corner, end, gate, pull posts - inch	Braces	Line Posts
Wire Fence & Farm Fence	2 1/2 x 2 1/2 x 2 1/4 or heavier	2" x 2" x 3/16" or heavier	Nominal Weight 1.33 lbs. per foot (exclusive of anchor plates)

The metal shall be a good commercial quality steel with maximum carbon content of 0.82 percent. Material conforming to commercial standard CS 184 will be accepted.

Line posts shall be Tee, H, channel or U-bar section and shall have corrugations, knobs, notches, holes or studs so placed and constructed as to engage a substantial number of fence line wires in proper position.

Each line post shall be provided with a steel anchor plate weighing not less than 0.67 pounds, tapered to facilitate driving and securely fastened to the post in such a position that its top edge will be two or three inches below the ground surface when the post is set to prescribed depth.

(I) Wood Fence Posts and Brace Rails. Posts and brace rails shall be made from Western Larch, Lodgepole Pine, Ponderosa Pine or Douglas Fir. They shall have the bark removed, be well seasoned, sound, and straight-grained. They shall be finished either natural round or square sawn. Line posts shall be four-inch minimum diameter, naturally round, or a minimum of four inch by four inch square sawn. Corner, end, gate, pull and brace posts shall be six inch minimum diameter, naturally round, or 5 1/2 inch x 5 1/2 inch square sawn.

Posts for farm fence may be multisided. Regardless of number of sides,

least cross-sectional area shall be at least 13 square inches for line posts and braces, and at least 29 square inches for corner, end, gate, and pull posts.

A post with a bow of more than 2 inches in 7 feet will be rejected.

Wooden posts for farm fence shall be treated with a minimum five percent by weight pentachlorophenol solution, or Copper Chromate Arsenate (CCA) type B or C, or Ammoniacal Chromate Arsenate (ACA) conforming to AWWA standards. Treatment must be done in such a manner and with a carrying agent that the preservative will penetrate the wood at least one-half inch or full sap. Treatment shall extend to a minimum length of thirty inches for line posts and thirty-six inches for other posts. The treated end shall be placed in the ground. Post treatment must be performed at a plant, approved by the laboratory, where all operations and quantities can be closely controlled.

All posts and timber used in constructing wire fence type CW, or CM fence with wood panels, shall be treated, as specified in Section M-270.

Posts that are to be driven into the ground shall be tapered in about eight to twelve inches to about a one-inch point on the lower end. The upper end shall be tapered for a minimum of four inches to a round top with a minimum diameter of three inches for line posts and five inches for corner, pull, end, brace and gate posts; this taper is included in the specified post length. Tapering shall be done prior to treatment. The requirement for extra length at the top will be waived, provided the contractor can drive the posts without damaging the upper end, as may be decided by the engineer.

(J) Metal Gates. Each gate shall be furnished complete with necessary hinges and latch and other hardware designed for use with the type of gate and gate post used on the project.

Metal gates used in conjunction with wire fence shall have a height of not less than 48 inches. The use of gates having greater heights will be permitted provided they do not extend above the top of the gate posts.

All metal gates shall be provided with one diagonal steel brace.

Metal gates shall be filled as completely as practicable, with galvanized wire fabric securely fastened to top, bottom and ends of gate frame. The fabric shall be a standard design compatible with the type of fence being constructed. All materials shall be galvanized class 1 or better, except commercial galvanizing is acceptable for metal farm fence gates.

A "double gate" shall consist of two single drive gates of equal width and conforming to the requirements of metal gates, supported at their exterior ends by gate posts and provided with a double gate spring latch holder, a top double gate stop and a bottom double gate stop for wire fence or their

equivalents for farm fence, at the interior ends of the gates so designed as to permit the gates to be fastened securely in a closed position. The tube for holding the fastening rod of the bottom double gate stop shall be securely imbedded in concrete. The width designation of a double gate, as it appears in the plans, is the approximate width of the opening, between gate posts, which the two single drive gates are to occupy when used jointly.

(1) Gates for Wire Fence. Metal gates shall be used for wire fence and shall be plain-top single drive gates of tubular steel frame with wire fabric filler. They shall be designed to fit openings, between gate posts, of the approximate widths called for by the plans. Single drive gates for openings of less than 14 feet shall be provided with one centered steel upright brace; and for openings of 14 feet or more, with two similar upright braces spaced at third-points in the gate width.

The weight of gates shall be about as set forth as follows:

Width of Opening	Approximate Weight
8	48 pounds
10	55 pounds
12	62 pounds
14	72 pounds
16	80 pounds

Heavier gates will be permitted if conforming otherwise.

(2) Gates for Farm Fence. Gates for farm fences shall be of the material and construction shown on standard drawings, or better. Type G-1 is wood, G-2 is barbed wire and G-3 is metal.

Metal gates shall be a good, substantial commercial product satisfactory to the engineer. All metal parts shall be galvanized.

(K) Deadmen or Anchor. Deadmen or anchors will be used at grade depressions, angle points and other places where unusual stresses will be exerted on the fence. A deadman shall weight at least 150 pounds and shall be buried in the ground with a cover of not less than two feet. It shall be a precast Portland cement concrete block constructed in accordance with the standard drawing, or other object satisfactory to the engineer. A deadman may be cast in place, when approved by the engineer. An anchor may be (a) a steel or iron bar or rod, at least 1 1/4 inch diameter by 3 feet long, with provisions on one end so that a brace wire can be securely retained, or (b) a section of galvanized metal line post at least 3 feet long, or (c) at substitute satisfactory to the engineer.

(L) **Concrete.** Concrete used as footings for fence posts, braces and other similar purposes shall be class "F", or better, as specified in Section 40.

(M) **Miscellaneous.** Bolts, nuts, fittings, hinges, and all other metal parts used in the construction of fences and gates shall be galvanized in accordance with the applicable ASTM designation.

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SECTION M-220

GUARD RAIL AND GUIDE POSTS

M-220.01 GUARD RAIL.

(A) Metal Beam and Fittings.

(1) **Steel Beam.** Steel beam guard rail units shall conform to AASHTO M-180.

All fittings shall be galvanized and conform to the requirements of ASTM A-153. Lengths of sections shall be such that splices will occur on posts. Where the rail is to be erected on a curve of radius less than 150 feet, it shall be shaped before erection.

(2) **Aluminum Beam.** Aluminum beam guard rail units shall be Alclad 2024-T3 (ASTM B 209 alloy clad CG42A-T3). Bolts shall be alloy 2024-T4 (ASTM B 211 alloy CG42A-T4). Nuts shall be alloy 6061-T6 (ASTM B 211 alloy GS11A condition T6). Washers shall be alloy 2024-T4 (ASTM B 209 alloy clad CG42A condition T4). Rail units and hardware shall be neither galvanized nor painted. Fabrication shall conform to the same requirements set forth in part (1) — shape, holes, lengths, etc. Terminal sections shall conform to Alclad 2024-T42 sheet (ASTM B 209 alloy clad CG42A-T42).

The rail element shall conform to the following table. The post connection shall withstand a 5,000 pound side pull in either direction.

Nominal Thickness of Sheet Inches	Minimum Tensile Strength of Joint Lbs.	Beam Strength			
		Traffic Side Up		Traffic Side Down	
		Maximum Deflection Load — Lbs.	Inch	Maximum Deflection Load — Lbs.	Inch
*	80,000	1,500	2.0	1,200	2.0
		2,000	3.0	1,600	3.0

(*) Sections must be interchangeable with steel beam — AASHTO M-180.

NOTE — Test shall be made with rail element freely supported on a twelve foot clear span and the load applied through a three inch flat surface at the center of the span.

(B) Posts.

(1) Wood Posts. Wood posts shall be Douglas Fir, Hemlock, Ponderosa Pine, Spruce, Larch or Lodgepole pine. Posts shall be straight, sound and relatively free from defects. All posts shall be round with a smooth surface or S4S with smooth surfaces. Shapes and dimensions shall conform to the current Standard Drawings.

Sawed posts prior to treating shall meet the requirements of construction grade posts and timber as set forth in the rules of the Western Wood products Association or other equivalent grading rules all of which shall conform to ASTM D-245.

The surface of the posts shall not vary more than one inch from a straight line connecting the ends. The posts shall be seasoned in a manner and to the extent that the remaining moisture content will not interfere with the prescribed treatment. Posts shall be treated with a minimum five percent by weight pentachlorophenol solution or Copper Chromate Arsenate (CCA) type B or C, or Ammoniacal Chromate Arsenate (ACA) conforming to AWWA standards. The minimum depth of penetration shall be one-half inch. Such posts shall not be painted unless specified. When subjected to testing as a simple beam with a 24 inch span and center loading applied to the back of a post, the post shall withstand a load of at least 30,000 pounds at failure.

(2) Concrete Posts. Concrete posts shall be precast and shall meet the requirements of the design and requirements stipulated in the contract or shown on the plans. Concrete shall be class "DD", or a concrete of equal strength, meeting the requirements of Section 40. Reinforcing steel shall meet the requirements of Section M-290. Size and shape shall conform to standard drawings.

(3) Light Weight Concrete Guardrail Posts and Guide Posts. Guardrail Posts and Guide Posts may, at the contractor's option, be produced from light weight aggregates.

Both fine and coarse aggregates for light weight concrete shall be produced by expanding, calcining or sintering such products as blast furnace slag, clay, diatomite, shale or slate.

The aggregates shall comply with AASHTO M-195. Separate fine and coarse aggregate shall be used and the fine aggregate used shall be the size designated as No. 4 to 0. The Coarse aggregate used shall be either the size designated as three-quarter inch to No. 4 or one-half inch to No. 4.

Reinforcing steel shall meet the requirements of Section M-290. Size and shape shall meet the requirements of the Standard Drawings.

The engineer may require pre-wetting of certain types of aggregate used.

The "freezing and thawing" test, AASHTO M-195, is waived.

The concrete produced from these aggregates shall have a minimum compressive strength of 3,000 psi (equal to Class DD Concrete), with a maximum absorption of 15 percent by volume and a maximum unit weight of 115 lbs. per cubic foot.

(4) Steel Posts. Steel posts shall meet the requirements stipulated in the contract or as shown on the plans or standard drawings.

(5) Aluminum Posts. Aluminum posts shall meet the requirements as specified in the contract or as shown on the plans or as in the special provisions.

(C) General.

(1) Wood Treatment. All posts shall be pressure treated with a five percent by weight pentachlorophenol solution or Copper Chromate Arsenate (CCA) type B or C, or Ammoniacal Chromate Arsenate (ACA) conforming to AWPA standards. Chamfering and other required framing and boring of bolt holes shall be performed prior to treating the material. Holes made for determination of penetration of preservative shall be plugged with tight fitting treated wood plugs. The requirements of Article M-270.06 (B) Incising, is waived for round wood posts of Ponderosa Pine.

(2) Painting. When specified, paint and painting shall meet the requirements of Article 91.06 (B) (4) and (C).

M-220.02 GUIDE POSTS.

(A) Wood Posts. Wood posts shall conform to the applicable provisions of Article M-220.01 (B) (1) and (C) (1). Size and form shall conform to applicable standard drawings.

(B) Concrete Posts. These shall conform to Article M-220.01 (B) (2) or (3) and standard drawings.

(C) Steel Posts — Type 1. Type 1 steel posts shall conform to Article M-320.01, part (D) (1) and part (D) (2) (b). All posts shall be galvanized.

(D) Metal Posts — Type 2. These posts shall be a good commercial quality steel. They shall be standard T, I, U, or L with a minimum weight of 1.33 lbs. per foot. Posts shall be galvanized in accordance with ASTM A-123 or painted in accordance with good manufacturing practice. An anchor plate will not be required. See standard drawing.

(E) Corrugated Metal Posts — Type "A" and "B". See standard drawing. The corrugated metal shall be gage 16, of size and shape shown on the drawing. The base metal and galvanizing shall meet the requirements of AASHTO M-36; galvanizing shall be done after cutting and after the backing plates have been welded in place. The metal U post used with type "B" shall conform to part (C) above as well as the drawing.

(F) Flexible Guide Posts. These posts shall be seamless polyethylene extrusion with a one-eighth inch minimum wall thickness and with a minimum weight of one pound per foot. The cross section of the post may be round, triangular or some other shape but must provide a minimum viewable width of four inches. A permanent installation shall be as detailed in the Standard Drawings. Temporary installations may be epoxy cemented or nailed to the pavement surface. Color of the polyethylene post shall be white or orange as specified.

(G) Hardware. Backplates or faceplates for posts and delineators shall meet the requirements shown on the standard drawings.

Bolts, nuts or studs which fasten the backplate to the post shall be galvanized in accordance with ASTM A-153 or they may be cadmium plated. Nuts and studs shall be an approved "vandal resistant" design.

Other miscellaneous hardware shall be galvanized in accordance with ASTM A-153.

SECTION M-270

TREATED AND UNTREATED TIMBER

M-270.01 STRUCTURAL TIMBER AND LUMBER. Structural timber and lumber shall meet the requirements for the numerical stress values shown on the plans, or as otherwise specified, when graded by rules developed in accordance with ASTM D-245. Any commercial grading rules that will provide material of an equal or greater stress value may be used.

Unless otherwise specified, only pieces consisting of sound wood, free from any form of decay, are acceptable.

When untreated timber is specified, it shall show not less than 85 percent heartwood on the girth, measured at the point where the least amount of heartwood occurs on any girth. When treated timber is specified, there will be no heartwood requirements and the amount of sapwood will not be limited.

M-270.02 LUMBER. Lumber shall be of the kinds and grades shown on the plans.

M-270.03 POLES AND POSTS. Round poles and posts shall be of the kinds indicated on the plans.

M-270.04 TREATED TIMBER. Treated timber shall be structural timber conforming to the requirements of the plans and specifications and treated with a timber preservative as hereinafter specified.

(A) Treated timber shall be treated by a pressure method to retain at least the minimum quantity, per cubic foot, of the preservative treatment stipulated.

The preservative shall be one of the following. Creosote oil, creosote coaltar solution, five percent by weight pentachlorophenol solution, Copper Chromate Arsenate (CCA) type B or C, or Ammoniacal Chromate Arsenate (ACA). They shall conform to AWWA standards unless otherwise specified.

Material to be painted shall be treated in a manner and with preservatives so that the paint will readily adhere to the resulting surface without discoloration.

All preservatives used and all methods of sampling and testing shall meet the requirements of AASHTO M-133.

(B) Incising. All lumber treated with creosote, creosote coal-tar solution, five percent by weight pentachlorophenol, (CCA) type B or C conforming to AWPAs standards whose least dimension is two inches or over, shall be incised in a suitable power driven machine. Lumber having a thickness of three inches and over shall be incised on all four sides. Lumber less than three inches thick shall be incised on the wide faces only, except where indicated on the drawings. The spacing and shape of the cutting teeth and the method of incising shall be such as to produce a uniform penetration. (One and one-half inch center matched material used for flumes, boxes, etc., shall not be incised).

The depth of the incision shall not be less than the following:

Size (inches)	Minimum Depth of Incision
1½ x 12.....	3/8 in.
3 x 12.....	7/16 in.
4 x 12.....	1/2 in.
8 x 10.....	9/16 in.
10 x 12.....	5/8 in.
12 x 12.....	3/4 in.
Intermediate sizes in proportion.	

(C) Inspection. Each shipment of lumber to be treated shall be inspected at the treating plant, both before and after treatment, by an inspector designated. The inspector shall stamp the ends of each accepted piece with a suitable stamp which has been copyrighted by him, of which a true impression has been filed with the Department of Highways. The inspector also shall file with the Department of Highways an itemized report of all timber inspected, giving temperatures, amount of preservative, time of treatment, lengths and sizes of timbers, total footage, and other pertinent information. Treated timber which does not bear, in legible form, the stamp of the inspector shall not be shipped from the treating plant.

Each shipment of untreated lumber shall be inspected at its source by an inspector designated insofar as is economically practical. In cases where the engineer deems inspection at the source to be impractical, the material may be accepted on the basis of a "Certificate of Inspection" from a grading or inspection bureau or agency recognized as being competent.

The acceptance of any material or finished members by the inspector shall not prevent their subsequent rejection, if found defective. Rejected material and workmanship shall be replaced promptly or made good by the contractor.

SECTION M-280

PAINTS

M-280.01 PIGMENTS, VEHICLES AND THINNERS. All materials from which paints are made and formulated shall comply with the specifications set forth below opposite successive item numbers:

(1) Basic Carbonate White Lead Pigment	ASTM D 81
(2) Basic Sulfate White Lead Pigment	ASTM D 82
(3) Zinc Oxide Pigments	ASTM D 79
(4) Mineral Iron Oxide Pigments	ASTM D 768
(5) Pure Chrome Green Pigment	ASTM D 212
(6) Iron Blue Pigment	ASTM D 261
(7) Lead Zinc Oxide Pigment	ASTM D 80
(8) Zinc Sulfide Pigments	ASTM D 477
(9) Calcium Carbonate Pigments	ASTM D 1199
(10) Titanium Dioxide Pigments	ASTM D 476
(11) Bone Black Pigment	ASTM D 210
(12) Carbon Black Pigment	ASTM D 561
(13) Black Synthetic Iron Oxide Pigment	ASTM D 769
(14) Red and Brown Iron Oxide Pigments	ASTM D 84
(15) Ochre (Ferrous earthy pigments)	ASTM D 85
(16) Raw and Burnt Umber (Pigments)	ASTM D 763
(17) Raw and Burnt Sienna (Pigments)	ASTM D 765
(18) Venetian Red Pigment	ASTM D 767
(19) Copper Phtalocyanine Blue Pigment	ASTM D 963
(20) Iron Blue Pigment	ASTM D 261
(21) Ultramarine Blue Pigments	ASTM D 262
(22) Blue Lead Pigment (Basic Sulfate)	ASTM D 405
(23) Reduced Chrome Green Pigment (grinders green)	ASTM D 213
(24) Chrome Oxide Green Pigment	ASTM D 263
(25) Chrome Yellow and Chrome Orange Pigments	ASTM D 211
(26) Basic Lead Silico - Chromate Pigment	ASTM D 1648
(27) Yellow Iron Oxide Pigment—hydrated	ASTM D 768
(28) Red Lead Pigment	ASTM D 83
(29) Aluminum Pigments	ASTM D 962
(30) Zinc Dust (pigment)	ASTM D 520

(31) Magnesium Silicate Pigments	ASTM D 605
(32) Diatomaceous Silica Pigments	ASTM D 604
(33) Mica Pigment	ASTM D 607
(34) Raw Linseed Oil	ASTM D 234
(35) Boiled Linseed Oil	ASTM D 260
(36) Spirits of Turpentine	ASTM D 13
(37) Petroleum Spirits (Mineral Spirits)	ASTM D 235
(38) Lampblack	ASTM D 209
(39) Liquid Paint Driers	ASTM D 600
(40) Raw Tung Oil	ASTM D 12

M-280.02 PAINTS AND ENAMELS. Paints and enamels shall be formulated and made as provided in the specifications listed below by formula numbers:

(1) Foliage Green Bridge Paint AASHTO M 67

(2) Black Bridge Paint AASHTO M 68

When two coats of this paint are required, sufficient red lead shall be used to tint the first coat so as to provide a contrast with the second coat.

(3) Aluminum Paint AASHTO M 69

Aluminum Paint, Ready Mixed, shall meet the requirements of Federal Specification TT-P-38.

(4) White and Tinted Ready-Mixed Paint AASHTO M 70

Second coat white (body) and third coat white (finish) shall be type 1, class 'A'; as an alternative, Federal specification TT-P-102, class A, will be accepted. This also applies to other colors.

(5) Red Lead (Dry and Paste-in-oil) and paint made therefrom AASHTO M 71

(6) Red Lead Ready-Mixed Paint AASHTO M 72

Use type I for shop coat and type IV for first field coat.

(7) Basic lead silico-chromate paint shall meet the requirements of Federal Specification TT-P-615d, Type II, and current amendments thereto unless otherwise specified on the plans or approved by the engineer.

(8) First coat white (prime) for use on wood, shall be made up of 100 pounds white lead paste (9% linseed oil) which may be either item 1 or item 2, Article M-280.01, or a mixture thereof.

5 gallons raw linseed oil — Item 11,

2 gallons turpentine — Item 13,

1 pint drier — Item 19,

(9) Black paint to be used on wood shall be made of 20 pounds lampblack — Item 18,

4 1/2 gallons raw linseed oil	— Item 11,
2 quarts turpentine	— Item 13,
1 pint drier	— Item 19,

(10) When basic lead silico-chromate paint Type II is used as a prime coat and the first field coat, one ounce of lamp black per gallon shall be added to the first field coat.

(11) Items 1, 2, 3, 5, 6, and 7, Article M-280.01 to be used on metal bases, unless specified otherwise. Items (6) and (7) are acceptable as prime or shop coat. Items 4, 8, and 9, Article M-280.02 are to be used on wood bases, unless specified otherwise.

(12) Equipment Enamel. Shall be formulated in accordance with Federal Specification TT-E-489b, class A; spray or brush consistency as specified; color shall match the appropriate color chip which is available, on request, from the State of Montana, Department of Highways, Materials Bureau, Helena, Montana 59601. Thinner, conforming to Federal Specification TT-T-306, shall be used, when necessary, at a rate not to exceed one pint per gallon.

(13) Traffic Line Paint. Traffic line paint, such as generally used on highway centerlines and at intersections, shall conform to the following requirements:

(a) **Materials.** The choice of class, type and brand of all ingredient materials is left to the discretion and ingenuity of the manufacturer. Sample of ingredient materials may be required for reference purposes. Rubber-base paint will be considered and will be subject to the approval of the laboratory. All materials shall conform to the latest revised American Society for Testing Materials specifications wherever such specifications apply.

(b) **Manufacture.** The ingredient materials shall be mixed and ground to produce a homogenous paint, free of foreign material, which will not thicken, gel, liver, curdle or settle on long periods of storage, and shall be readily broken up to a uniform condition capable of application without clogging the spray gun nozzle or causing other operating difficulties. The paint must dry to an elastic adherent finish and show no appreciable discoloration with age. The volatile material shall have a minimum solvent action on asphalt. The non-volatile matter shall be of such quality that it will not darken or become yellow when a thin section is exposed to sunlight. The manufacturer's equipment and process shall be made available for inspection by an authorized inspector.

(c) **Analysis.** All prospective suppliers shall be required to furnish a notarized analysis and manufacturer's guarantee in triplicate. Such

analysis shall state the complete composition and shall show the percentages of each of the raw materials used in formulating the paint. The manufacturer's guarantee shall certify that the paint will comply with these specifications. The manufacturer's formulation will be treated as confidential and will not be revealed without his consent.

(d) Pigment. The pigment for yellow traffic line paint shall be a combination of inorganic colors and white pigment to produce the proper color.

Yellow paint, less beads, shall contain a minimum of 1.85 lbs., total chromium per gallon, as PbCrO_4 in the form of medium chrome yellow type III, Total chromium will be determined upon chemical analysis of the extracted pigment. White paint, less beads, shall contain a minimum of 1 1/2 lbs. of titanium dioxide per gallon as determined from the chemical analysis of total titanium dioxide in the extracted pigment.

(e) Vehicle. The vehicle shall be an alkyd resin solution meeting the following specifications:

Non-Volatile.....	59-61%
Volatile.....	Mineral spirits or VM & P naptha
Viscosity (Gardner Holdt).....	z-z-4
Acid No. of Solution.....	10 Max.
Color (Gardner 1933 Std's)	9 Max.
Sp. Grav. of solution.....	.920-.950

The non-volatile vehicle shall be an alkyd resin consisting only of:

Polyhydroxyl Alcohol.....	15-21%
Phthalic Anhydride.....	30-40%
Drying Oil Acids.....	45-60%

The resin shall not exceed 1% unsaponifiable matter by weight. The resin shall show a negative resin test and a negative phenolic compound test. The drying oils shall be limited to linseed and/or soybean oil.

(f) Color. A standard color chip will be furnished each bidder for the yellow and white traffic line paint, if and when the engineer so desires.

(g) Viscosity. The viscosity shall be seventy (plus or minus five) Krebs Units not less than four days after manufacture at 25°C . and shall not be more than ninety Krebs Units at 5°C .

(h) Drying Time. When tested by the prescribed method, the paint shall dry to no pickup in not less than 10 minutes and not more than 30 minutes and shall dry hard within one hour.

(i) **Bleeding.** There shall be no bleeding or discoloration of the paint film when subjected to the prescribed test.

(j) **Water Test.** There shall be no blistering, peeling, or wrinkling of the paint film when subjected to the prescribed test.

(k) **Flexibility.** The film shall not crack when subjected to the prescribed flexibility test.

(l) **Adhesion.** There shall be no cracking, chipping, or peeling when subjected to the prescribed adhesion test.

(m) **Fineness.** The fineness of grind shall not be less than 3 when tested by the North Standard Fineness Gage.

(n) **Skinning.** There shall be no skinning in a half filled pint container in less than 24 hours.

(o) **Settling.** The pigment shall not settle or cake in the container on long periods of storage. An accelerated method of settling evaluation is listed under test.

(p) **Abrasion.** When subjected to the specified Taber Abrasion test, the loss in weight of paint film shall not be more than one-tenth gram per one thousand revolutions.

(q) **Hiding.** The paint shall completely hide black when applied at the rate of one gallon per 175 square feet.

(r) **Film Appearance.** The paint shall dry to a flat finish.

(s) **Testing Procedure.** Testing of the paint shall be in accordance with the methods specified by the American Society for Testing Materials, Federal Test Method Standard No. 141, latest revision, or alternative tests and methods approved by the engineer.

(t) **Light Resistance.** Yellow paint shall not darken appreciably when subjected to the prescribed test.

(u) **Samples.** Vacant.

(v) **Rejection of Materials.** After the paint has been delivered, the engineer may take representative samples from the containers during the progress of the work and examine the samples for compliance with the specifications. Should the paint develop any condition denoting failure to comply with the specifications, prior to final acceptance, the paint shall be rejected.

(w) **Packaging & Marking.** Paint shall be delivered in such capacity containers as may be ordered. Paints manufactured under these

specifications shall be shipped in containers constructed, sealed and packed so as to withstand rough handling. If 5-gallon containers are used they shall be of pressed steel. Paints received at destination in a damaged condition shall be rejected. Each container shall bear a label with the following information shown thereon: Name and address of the manufacturer, shipping point, trademark or trade name, kind of paint, formula, or formula number referring to manufacturer's guaranteed formula, number of gallons, date and batch numbers.

(x) Reflective Glass Beads. This specification covers glass beads intended for use in reflectorizing traffic paint markings on pavement by the drop-on method.

(a) General Requirements. The glass beads shall be spherical in shape and transparent with smooth, lustrous surfaces. The beads as delivered shall be free from extraneous material and clumps of beads which cannot be broken up easily in the process of handling and distribution to the stripe.

(b) Detail Requirements.

1. Imperfections — The glass beads shall not include more than twenty percent irregularly shaped particles when tested according to ASTM D-1155. The beads shall be free of scratches, pits, milkiness, dark particles and excessive air bubbles.

2. Color — The glass beads shall be colorless to the extent that they do not impart a noticeable daytime hue to white pavement markings.

3. Chemical Stability — The beads shall withstand refluxing in distilled water in a Soxhlet extractor for 90 hours without noticeable dulling of surface luster and not more than 2.5% loss in weight.

4. Index of Refraction — The glass of which the beads are composed shall have an index of refraction of not less than 1.50 by the immersion method using tungsten light.

5. Gradation — The glass beads shall meet the following gradation requirements when tested in accordance with Standard Method of Test for Sieve Analysis of Glass Spheres, ASTM D-1214.

<u>SIEVE NO.</u>	<u>TOTAL PERCENT PASSING</u>
20	100%
30	75-95%
50	15-35%
100	0-5 %

(c) Packaging & Marking. Glass beads shall be furnished in bags containing 50 pounds net.

The shipping bags shall be moistureproof, paper lined burlap bags conforming to specification ICC-36-C under Interstate Commerce Commission Regulation Section 78-234. Each bag shall be marked with name of contents, manufacturer of beads and net weight.

(d) Samples.

Personnel of the Department of Highways will be responsible for submitting to the Department laboratory a one-half pound sample of the beads to be used. No beads shall be applied before they have been approved for use.

(14) White, Yellow and Black Enamel for Metal. These shall be water-resisting enamels made with synthetic gums. They shall be suitable for brush application to vertical metal surfaces without running, streaking or sagging, and shall conform to characteristics set forth below:

	White	Yellow	Black
Coarse particles and skins retained on No. 325 sieve, not over.....	0.50%	0.50%	0.50%
Nonv-volatile matter, not less than.....	85%	85%	85%
Set to touch at room temperature, not over, hours.....	5	5	5
Dry hard at room temperature, not over, hours.....	24	24	24
Toughness, Kauri reduction test at 75° F., not less than.....	150%	150%	120%
Hiding power, square feet per gallon by Pfund cryptometer, Model E, black plates, not less than.....	300	450	---

The dried films must withstand cold water for 18 hours and boiling water for 15 minutes without whitening, dulling or change in color. The enamels shall have good brushing, flowing, covering and leveling properties and must not cake in the container. The properties set forth above shall be determined in accordance with Federal Test Method Standard No. 141.

The white enamel shall be equal in brightness to that obtainable with rutile titanium-calcium pigment (ASTM D 476). Yellow enamel shall match a standard color sample for D-2 yellow guard rail paint. Black enamel shall be jet black and hide completely in one coat.

(15) **Brilliant Green Sign Enamel.** This enamel shall be a ready-mixed exterior paint meeting the requirements of Federal Specification TT-P-71b, except that a blend of titanium dioxide and tinting pigments shall be used instead of chrome green oxide. The paint shall match the color of a standard green sign enamel. It shall, when reduced with an equal weight of linseed oil, have a hiding power of not less than 750 square feet per gallon when measured on the Pfund Cryptometer Model E, white plate, viewed in a light of approximately 50 foot-candle intensity.

(16) **Pretreatment for Rusted and Galvanized Surfaces.** Such areas shall be treated with a freshly prepared solution of phosphoric acid conforming to Military Specification Mil-P-15328, diluent (A).

(17) **Concrete Paint.**

(A) **White.** Concrete white paint shall consist of any suitable mixture of white pigments ground into a varnish base vehicle free from benzol and chlorinated solvents.

- (1) **Composition shall conform to the following by weight:**
- | | |
|--|-----------|
| Total non-volatile material including | |
| Pigment..... | 60% Min. |
| Non-volatile material in vehicle..... | 35 to 45% |
| Water..... | 1.0% Max. |

(2) The clear vehicle extracted with a super centrifuge shall pass a zero percent Kauri Reduction Test.

(3) **Drying Time.** A medium brush coat on glass shall dry to touch in not less than 15 minutes or more than 2 hours and shall dry hard in not more than 16 hours.

(4) Daylight reflectance shall be not less than 75% relative to magnesium oxide.

(5) Consistency shall be not less than 65 nor more than 85 K.U.

(6) Dry Opacity shall be not less than 0.88 with the film applied with a 0.0025 inch Bird Film Applicator.

(B) **Black.** Concrete black paint shall be a mixture of tar pitch and oils which are light tar distillates and shall meet the following requirements:

- (1) Viscosity, Saybolt Furol at 77° F. shall not exceed 100 seconds.
- (2) Water content shall not exceed 1.0% by weight.
- (3) When distilled according to ASTM D 20 the amount of distillate up to 572° F. shall be from 25% to 40%.

(4) The color shall be a dense lustrous black.

(5) At 70° F. the paint shall dry to touch in 20 minutes and dry free from tackiness in 45 minutes.

(18) **Dark Olive Green Finish Coat:**

(A) **General Requirements.** All paints shall be well ground and show no skinning in a freshly opened full can. Paints shall not cake in the container or settle badly and shall be capable of being readily broken up with a paddle to smooth uniform consistency. Paints shall brush easily, possess good leveling and dry to a hard, uniform finish. The composition of the paints shall meet the following requirements:

	<u>Min.</u>	<u>Max.</u>
Pigment.....	59.0%	.....
Vehicle.....	.....	41.0%
Pigment Portion:		
Basic Lead Silico-Chromate.....	88.0%	.....
Chromium Oxide Green.....	9.0%	.....
Pthalocanine Green.....	0.7%	.....
Bentone 34.....	0.3%	0.7%
Vehicle Portion:		
Raw Linseed Oil.....	45.0%	.....
Alkyd Resin Solids (TT-R-266, Type I).....	28.0%	.....
Mineral Spirits and Driers.....	.....	27.0%
Finished Paint:		
Consistency (Krebs-Stormer).....	74 KU	84 KU
Weight Per Gallon.....	14.1 Lb.	.....
Dry to Touch.....	.....	8 Hr.

(19) **Montana Blue or Montana Brown.**

(A) **General Requirements.** The shop and first field coat shall be in accordance with Section 91 of the Standard Specifications. The second field coat shall be either, Montana Blue, No. 55-10 or Montana Brown, No. 76-23, whichever is called for on the plans. Either color shall match the appropriate color chip which is available, upon request, from the State of Montana, Department of Highways, Materials Bureau, Helena, Montana, 59601.

All paints shall be well ground and show no skimming in a freshly opened full can. Paints shall not cake in the container or settle badly and shall be capable of being readily broken up with a paddle to smooth uniform consistency. Paints shall brush easily, possess good leveling and

dry to a hard uniform finish. The composition of the Montana Blue and the Montana Brown paint shall meet the following requirements:

	<u>Min.</u>	<u>Max.</u>
Pigment.....	56.5%	58.5%
Vehicle.....	41.5%	43.5%
Pigment Portion:		
Zinc Phosphate.....	60.0%	.....
Titanium Dioxide (Rutile)	13.0%	.....
Calcium Carbonate.....	21.4%	.....
Vehicle Portion:		
Alkyd Phthalic Resin (50% Solids)	52.4%	.....
Raw Linseed Oil.....	26.2%	.....
Mineral Spirits.....	17.2%	.....
Driers and Additives.....	4.2%	.....
Finished Paint:		
Consistency (Krebs-Stormer).....	70 K.U.	83 K.U.
Weight Per Gallon	12.6 lbs.	.....
Dry to Touch.....	.....	8 Hours
Dry to Handle.....	.....	16 Hours
Dry Film Thickness.....	1.0 Mil.	.....

For additional requirements for painting see Section 91 of the Standard Specifications.

SECTION M-290

REINFORCING STEEL, STRUCTURAL STEEL, HARDWARE AND MISCELLANEOUS STRUCTURE ITEMS

M-290.01 REINFORCING STEEL.

(A) **Bar Reinforcement.** Reinforcement steel shall be of the deformed type and shall meet the requirements of ASTM A-615, (AASHTO M-31), Grades 40 or 60 as noted on the plans.

Where purchased from warehouse in small lots, reinforcing steel may, at the direction of the engineer, be accepted subject to the bending test as specified in ASTM A-615 or AASHTO M-31.

The test specimen shall bend cold around a pin without cracking on the outside of the bent portion.

(B) **Wire and Wire Mesh.** Wire shall conform to the specification for cold-drawn steel wire for concrete reinforcement, of AASHTO M-32 (ASTM A-82).

Wire mesh, when used as reinforcement in concrete shall conform to the specification for welded steel wire fabric for concrete reinforcement of the AASHTO M-55 (ASTM A-185). The type of mesh shall be approved by the engineer.

Bar mats shall conform to the requirements of AASHTO M-54.

M-290.02 STRUCTURAL STEEL. Unless otherwise specified, structural steel for riveted, bolted or welded construction shall conform to the requirements for Structural Carbon Steel, AASHTO M-183 (ASTM A-36). Steel for eyebars shall be of a weldable grade.

M-290.03 WROUGHT IRON. Vacant.

M-290.04 PINS AND ROLLERS. Pins and rollers shall be structural carbon steel conforming to the special provisions or as noted on the plans.

M-290.05 WELDING ELECTRODES. Unless otherwise specified, welding electrodes shall conform to the requirements for mild steel, arc welding electrodes ASTM A-233, AWS A 5.1.

M-290.06 HIGH TENSILE STRENGTH BOLTS. Heat treated carbon steel bolt, nut and washer material, unless otherwise specified, shall conform to the requirements of AASHTO M-164, (ASTM A-325).

M-290.07 BOLTS AND NUTS. Bolts and nuts shall conform to the requirements of ASTM A-307 Grade A with hexagonal heads and nuts, for steel machine bolts and nuts and tap bolts.

M-290.08 STEEL PIPE. Vacant.

M-290.09 GALVANIZED METAL. When galvanizing is shown on the plans or specified in the special provisions, ferrous metal products shall be galvanized in accordance with the Specifications for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars and Strip AASHTO M-111 (ASTM A-123).

M-290.10 WELDED STUD SHEAR CONNECTORS. Shear connector studs shall be in accordance with the requirements of the AWS specification for "Stud Welding" as called for in the contract.

M-290.11 STRUCTURAL STEEL PILES. Vacant.

M-290.12 PRESTRESSING STEEL. High tensile wire prestressing steel shall conform to ASTM A-416 except as noted on the plans.

M-290.13 SHEET LEAD. Sheet lead shall conform to the requirements for common desilverized lead of the specification for pig lead AASHTO M-112 (ASTM B-29).

M-290.14 SHEET ZINC. Sheet zinc shall conform to the requirements for type II of the specifications for rolled zinc, AASHTO M-113 (ASTM B-69).

M-290.15 TESTING PRESTRESSING REINFORCEMENT AND ANCHORAGE. All wire, strand, or bars to be shipped to the site shall be assigned a lot number and tagged for identification purpose. Anchorage assemblies to be shipped shall be likewise identified.

All samples submitted shall be representative of the lot to be furnished and, in the case of wire or strand, shall be taken from the same master roll. All of the materials specified for testing shall be furnished free of cost and shall be delivered in time for tests to be made well in advance of anticipated time of use. Where the engineer intends to require non-destructive testing of one or more parts of the structure, special specifications shall be drawn giving the required details of the work.

The vendor shall furnish for testing the following samples selected from each lot. If ordered by the engineer, the selection of samples shall be made at the manufacturer's plant by the inspector.

For pretensioned strands, samples at least seven feet long shall be furnished of each strand size. Sample shall be taken from each end of every coil.

M-290.16 CASTINGS. Castings shall conform to the requirements of the following specifications:

(A) Steel castings for highway bridges—AASHTO M-192 Class 70 shall be furnished unless otherwise specified.

(B) Chromium alloy steel castings AASHTO M-163 (ASTM A-296). Grade CA-15 shall be furnished, unless otherwise specified.

(C) Gray iron castings AASHTO M-105 (ASTM A-48).

Class No. 30 shall be furnished unless otherwise specified. Iron castings shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes, and other defects in position affecting their strength and value for the service intended. Castings shall be boldly filleted at angles and the arrises shall be sharp and perfect. All castings must be sandblasted or otherwise effectively cleaned of scale and sand so as to present a smooth, clean, and uniform surface.

(D) Malleable castings AASHTO M-106 (ASTM A-470).

Grade No. 35018 shall be furnished unless otherwise specified. The requirements for workmanship, finishing, and cleaning shall be the same as above for gray iron castings.

M-290.17 CANVAS AND RED LEAD FOR BEDDING MASONRY PLATES AND EQUIVALENT BEARING AREAS. Canvas shall conform to the standard specifications for Numbered Cotton Duck and Army Duck of AASHTO M-166 (ASTM D-230,) and to the weight specified. Red lead shall conform to the specification for paint, Art. M-280.02.

M-290.18 BEARING ASSEMBLY ANCHOR BOLTS FOR BRIDGES. Anchor bolts shall be of the sizes designated on the plans and shall conform to the requirements of ASTM A-36 unless specified otherwise.

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SECTION M-310

LIGHTING & SIGNAL MATERIALS

M-310.01	General.....	587
M-310.02	Ducts & Conduits	587
	Part (A) Plastic Conduit	587
	Part (B) Steel Conduit.....	587
M-310.03	Miscellaneous Hardware	587
	Part (A) General.....	587
	Part (B) Galvanizing	588
	Part (C) Bonding Straps.....	588
	Part (D) Concrete Pull Boxes	588
	Part (E) Metal Pull Boxes	588
M-310.04	Standards and Posts	589
	Part (A) General.....	589
	Part (B) Steel Shaft Type 2 and 3 Signal and Type 10 Luminaire Standards.....	589
	Part (C) Aluminum Shaft, Type A Luminaire Standards	590
	Part (D) Mast Arms - Signal and Luminaire.....	591
	Part (E) Signal Standards - Steel, Types 1-80, 1-100, 1-120, 1-140, 1-160, and Type A Controller Cabinet Pedestal	591
	Part (F) Welding.....	592
	Part (G) Finish.....	592
	Part (H) Wire Protection.....	592
	Part (I) Inspection	592
M-310.05	Conductors & Cable	592
	Part (A) General.....	592
	Part (B) Traffic Control Conductors & Multiple Circuit Lighting Conductors.....	592
	Part (C) Multi-Conductor Cables.....	592
	Part (D) Conductor Color Code	592
Table A	Color and Stripe Code of Wiring	594
M-310.06	Service Equipment.....	593
M-310.07	Controllers	593
	Part (A) General.....	593
	Part (B) Solid State Actuated Controller Equipment	595

Part (C) Semiactuated Controllers.....	600
Part (D) Two Phase Fully Actuated Controller	601
Part (E) Multi-Phase Controllers.....	602
Part (F) Main Frame With Power Supply.....	603
Part (G) Types of Phase Timing Units	605
Part (H) Operation Requirements of Phase Timing Units.....	607
Part (I) Operating Characteristics of Three-Phase Control Assemblies.....	611
Part (J) Operating Characteristics of Four-Phase Control Assemblies.....	611
Part (K) Multi-Phase Operation.....	612
Part (L) Control Assemblies	613
Part (M) Phase Timing Units	613
Part (N) Dual Maximum Operation	615
Part (O) Pedestrian Actuated Controllers.....	615
Part (P) Actuated Controller Cabinets	616
Part (Q) Railroad Interconnect	617
Part (R) Guarantee.....	619
Part (S) Pre-Timed Controllers.....	619
M-310.08 Traffic Signals and Appurtenances	622
Part (A) Signal Heads	622
Part (B) Directional Louvers	624
Part (C) Back Plates	624
Part (D) Mounting Brackets.....	624
Part (E) Signal Head Mounting.....	625
Part (F) Installing Signal Heads.....	625
Part (G) Pedestrian Signals	625
M-310.09 Detectors and Push Buttons.....	626
Part (A) Magnetic Detectors	626
Part (B) Loop Detector Installations.....	627
Part (C) Pedestrian Push Buttons.....	630
M-310.10 Lighting & Other Systems.....	630
Part (A) Luminaires.....	630
Part (B) Flashing Beacons	630
Part (C) Sign Lighting Fixtures	631
Part (D) Fluorescent Sign Lighting Fixtures.....	631
Part (E) Photo-Electric Controls	631
Part (F) Isolating Transformers & Ballasts	634
M-310.11 Overhead Conductor Lighting Installation.....	634

Part (A) Equipment	100
Part (B) Line Material	100

M-310.01 GENERAL.

All electrical equipment shall conform to the standards of the National Electrical Manufacturers (N.E.M.A.) or the Radio Manufacturers Association, whichever is applicable. In addition to the requirements of these specifications, the plans and the special provisions, all material and work shall conform to the requirements of the National Electrical Code, hereinafter referred to as the Code; the standards of the American Society for Testing Materials (A.S.T.M.); the American National Standards Institute (ANSI) and any state laws or local ordinance which may apply.

Wherever reference is made to the code, or the standards mentioned above, the reference shall be construed to mean current provisions of the code, order, or standard at the time the contract is let and shall govern throughout the life of the contract.

M-310.02 CONDUITS.

(A) Plastic Conduit. Conduit shall be composed of rigid polyvinyl chloride and shall conform to industry standards. Materials shall have a minimum heat distortion temperature of 165° F. at 264 psi, minimum Izod impact strength at 15 pounds/inch/notches, minimum tensile strength of rupture at 78° F. at 6000 psi, minimum crush strength of 1500 pounds per lineal foot. Wall thickness shall be 0.133 inch for one inch conduit, 0.145 inch for 1½ inch conduit and 0.154 inch for two inch conduit. Plastic conduit shall be suitable for direct burial and shall be installed in compliance with the provisions of Article 85.03.

(B) Steel Conduit. Rigid steel conduit and fittings shall conform to ANSI specification C 80.1. Size shall be as shown on the plans. Thin-wall or flexible conduit, and fittings, shall conform to ANSI specifications C 80.3. The interior of all conduits shall have a continuous coating of lacquer enamel or other suitable protective coating. Each length shall bear the label of Underwriters Laboratories, Inc.

M-310.03 MISCELLANEOUS HARDWARE.

(A) General. Junction boxes and conduits shall be of the size and detail shown on the plans. Anchor bolts shall conform to ASTM A-307, grade A, and shall be provided with two nuts and two washers each. Drain pipe for junction boxes shall be as shown on plans. Pull wire shall be No. 12 A.W.G.

(B) Galvanizing. Nuts, washers, junction boxes, anchor bolts, water pipe, pull wires and other ferrous parts shall be galvanized after fabrication in accordance with ASTM A-153 or other applicable ASTM galvanizing specifications; anchor bolts may, as an alternate, be cadmium plated with type NS coating conforming to ASTM A-165. Construction of bolts and nuts shall be such that nuts will go on to bolts without damage to the coating.

(C) Bonding Straps. Bonding straps on structures shall be flexible copper of the same cross-sectional area as No. 4 A.W.G. Strap clamps shall be bronze and shall be the proper size and type for the strap being used.

(D) Concrete Pull Boxes. Concrete manholes and pull boxes and covers shall be of the design shown on the plans or standard drawings. The concrete shall be class "DD" in accordance with Section 40. Reinforcing steel shall be in accordance with Section 47.

Pull boxes and extensions shall be reinforced concrete boxes of the sizes and details shown on the plans.

For signal systems, or combined signal and low voltage lighting systems, reinforced concrete covers shall be inscribed "Traffic Signals" and for lighting systems, reinforced concrete covers shall be inscribed "Street Lighting" ("High Voltage," where applicable). Covers shall be provided with two three-eighths inch brass hold down bolts with brass washers and nuts. Nuts shall be recessed below surface of cover.

Where pull boxes are to be placed in areas subject to traffic loads a steel cover of suitable design to withstand such loads shall be used in lieu of the concrete cover.

Pull box installations shall be made as water tight as possible. Covers shall be sealed with a one-quarter inch bead of asphaltic mastic in the cover recess. Conduit shall enter from the bottom of the box.

Pull boxes for structure installations shall conform to the dimensions and locations shown on the plans. Boxes or vaults formed in the concrete shall have metal frames and covers, with wording inscribed on the covers as shown on the plans. Gasket surfaces shall form a true plane. Gaskets shall be of one piece neoprene, one-eighth inch thick, and shall cover the contact surface between the frame and cover.

(E) Metal Pull Boxes. Metal pull boxes shall be installed where shown on the plans. The pull box shall be of cast iron construction and shall be a flush mounting sidewalk type box with a checkered steel cover, all hot dip galvanized. The cover shall screw to the pull box and be moisture sealed by gaskets. Conduit entrances shall be bossed, drilled and tapped as required.

M-310.04 STANDARDS AND POSTS.

(A) General. Standards for traffic signals, luminaires, cabinets, illuminated signs, and the like, shall be as specified or shown on the plan and shall conform to the applicable provisions of Section 43 and AASHTO's "Specifications for the Design and Construction of Structural Supports for Highway Luminaires." Standards shall be constructed according to the pole schedules and details on the plans or approved equivalent.

When specified, aluminum standards of equivalent strength may be substituted for steel luminaire standards. Aluminum standards will not be acceptable substitutes for steel signal standards or combination signal and luminaire standards.

Design wind velocity shall be 90 m.p.h. with gust speeds of 117 m.p.h.

(B) Steel Shaft-Type 2 and 3 Signal and Type 10 Luminaire Standards. The shaft shall be a single section formed into a round continuous taper with a single, automatic electrically welded seam. The shaft shall be designed to withstand the loads indicated on the plans. The shaft shall be a minimum No. 7 Manufacturer's Standard Gauge for signal standards and a minimum No. 11 Manufacturer's Standard Gauge for luminaire standards, or as specified. The shaft steel shall have a minimum yield strength of 33,000 p.s.i.

Standards without a transformer base will include a hand hole, minimum size four inches by six inches, circumferentially welded in the shaft. The hand hole will be located 18 inches above the bottom of the shaft and 90° clockwise in respect to the mast arm. A steel cover shall be provided and secured with hex-head cap screws.

Provisions shall be made, on the inside of and near the bottom of the shaft, for the attaching of a ground. The top of the shaft shall be provided with a rain-tight removable steel cap.

The factory shall: Provide an opening in the shaft for a wire entrance into the signal or luminaire mast arm; Provide a solid base around the opening for mounting the mast arm.

The threaded hub which provides a wire entrance and permits mounting of a controller or service cabinet shall be factory welded to the shaft prior to galvanizing.

Drilling and tapping for wire entry and for mounting of pedestrian and vehicle signals or pedestrian push buttons shall be field drilled and the holes or threads treated to prevent rusting.

All accessories that require welding to affix to shaft, shall be factory welded. The anchor base shall be a one piece steel anchor type, circumferentially welded to the shaft prior to galvanizing.

Transformer and slip type bases will be provided when specified. Transformer bases shall have a hand hole and a removable cover.

Provisions shall be made for plumbing a standard by using nuts and washers or factory made shims for transformer bases. Nut covers or base covers shall be provided and installed on bases when called for.

The space between the base and the foundation shall be filled with grout meeting the requirements of Article 50.13. A three quarter inch drain hole shall be formed in the grout at the lowest point. Anchor bolt size, circle and protrusion shall conform to the manufacturer's recommendations.

(C) Aluminum Shaft, Type A Luminaire Standards. The shaft shall be a one piece, seamless, round tapered tube of aluminum alloy. The shaft shall be designed to withstand the loads indicated on the plans and shall have a minimum wall thickness of 0.219 inch and a minimum outside base diameter of ten inches.

Standards without a transformer base will include a hand hole, minimum size four inches by six inches, circumferentially welded to the shaft. The hand hole will be located 18 inches above the bottom of the shaft and 90° clockwise in respect to the mast arm. An aluminum cover shall be provided and secured with hex-head cap screws.

Provisions shall be made, on the inside of and near the bottom of the shaft, for the attaching of a ground. The top of the shaft shall be provided with a rain-tight removable aluminum cap.

The factory shall: Provide an opening in the shaft for a wire entrance into the signal or luminaire mast arm; Provide a solid base around the opening for mounting the mast arm.

The threaded hub which provides a wire entrance and permits mounting of a controller or service cabinet shall be factory welded to the shaft prior to heat treatment.

Drilling and tapping for wire entry, if required, shall be field drilled and the holes or threads treated to prevent rusting.

All accessories that require welding to afix to shaft, shall be factory welded. The anchor base shall be a one piece cast aluminum type, circumferentially welded to the shaft.

Transformer and slip type bases will be provided when specified. Transformer bases shall have a hand hole and a removable cover.

Provision shall be made for plumbing a standard by using nuts and washers or factory made shims for transformer bases. Nut covers or base covers shall be provided and installed on bases when called for.

The space between the base and the foundation shall be filled with

grout meeting the requirements of Article 50.13. A three quarter inch drain hole shall be formed in the grout at the lowest point. Anchor bolt size, circle, and protrusion shall conform to the manufacturer's recommendations.

(D) Mast Arms - Signal and Luminaire. Mast arm may be a tapered single member or a truss type with a vertical strut brace between the upper and lower member.

Mast arms shall provide continuous internal wiring from the luminaire through the mast arm and into the shaft.

Mast arms shall terminate in a two inch pipe size slip fitter tenon at least six inches long for mounting the signal or luminaire. The tenon shall be factory welded to the mast arm.

All accessories that require welding to affix to a mast arm shall be factory welded.

Luminaire mast arm lengths and mounting heights are shown on the plans.

Signal mast arm lengths shall be as shown on the plans.

Minimum road clearance shall be 17 feet to the bottom of the signal back plates for all signals mounted on mast arms.

(E) Signal Standards - Steel, Types 1-80, 1-100, 1-120, 1-140, 1-160 and Type A Controller Cabinet Pedestal. The shaft shall be a single 4½ inch outside diameter standard steel pipe, except the 1-80 shall be 2½ inches outside diameter.

Provision shall be made on the inside of all shafts, near the base, for attachment of a ground. The top of all shafts will be raintight or provided with raintight removable covers if applicable.

Tapping and drilling for mounting of pedestrian and vehicle signals or pedestrian push buttons, shall be field drilled and the holes or threads treated with a rust preventative.

All accessories that require welding, to affix to the shaft, shall be factory welded.

The anchor base shall be a one piece steel anchor type, circumferentially welded to the shaft prior to galvanizing.

When two or more conduits enter the shaft base, the base shall be a single piece, cast-steel-type, internally threaded to match the threads on the base of the shaft. It shall be furnished with a handhole and removable cover.

Provision shall be made for plumbing a standard by using nuts and washers or factory made shims for transformer bases. Nut covers or base covers shall be provided and installed on bases when called for.

The space between the base and the foundation shall be filled with grout meeting the requirements of Article 50.13. A three quarter inch drain hole shall be formed in the grout at the lowest point. Anchor bolt size, circle and protrusion shall conform to the manufacturer's recommendations.

(F) Welding. All welding shall meet the requirements of the current (see Article 06.03) Specifications for Welding of Structural Steel Highway Bridges, as amended by AASHTO and the Montana Supplemental Specifications for Welding.

(G) Finish. Steel standards shall be galvanized inside and out. Aluminum standards shall have a polished aluminum surface. A primer finish will not be accepted unless specified. All fasteners shall be stainless steel or have an appropriate zinc, cadmium or galvanized finish. Anchor bolts shall be high strength steel with the threaded ends galvanized. The nuts, washers and shims for the anchor bolts shall be galvanized.

(H) Wire Protection. All openings and inlets for wire shall be designed to use insulated bushing or grommets to protect against wire abrasion.

(I) Inspection. All standards will be inspected at the site before erection is authorized and when warranted will be inspected at the point of fabrication.

M-310.05 CONDUCTORS AND CABLE.

(A) General. Conductors and cable shall conform to the applicable specifications as follows:

(B) Traffic Control Conductors and Multiple Circuit Lighting Conductors. Insulation shall be designed for 600 volts. Conductors (unless otherwise specified) shall be single conductor, solid, or stranded copper of gauge as shown on the plans, insulated with THW grade plasticized polyvinyl chloride compound. Copper wire shall conform to the applicable portions of ASTM B-3 and ASTM B-8. The insulation shall conform to the applicable portions of ASTM D-2219 and D-2220 and thickness per table 5.

(C) Multi-conductor Cables. These shall be used when specified or approved by the engineer.

Cable shall meet the applicable International Municipal Signal Association (IMSA) specifications 19 and 20.

(D) Conductor Color Code. For traffic signal and multiple circuit

street lights and signs, the insulation of single conductors shall be of solid color and permanent colored stripe to identify conductors as details in Table A, unless otherwise specified.

When multi-conductor cable is used, wiring shall be according to color code or wiring diagram.

At controller cabinets and at signal poles, cables shall be tagged to show routing. Individual wires shall be tagged to indicate phase and signal color.

M-310.06 SERVICE EQUIPMENT. Service fittings for multiple lighting or traffic signal systems or both shall include a two-wire or three-wire solid neutral, 120- or 120-240 volt service circuit breaker or service switch, in a raintight housing together with a safety socket box or meter socket or both, located as specified by the power serving utility and as specified or shown on the drawings. Each service switch or service circuit breaker shall be provided with hasp for padlock to be furnished by others.

M-310.07 CONTROLLERS.

(A) General.

(1) Definition. A controller shall consist of a complete electrical unit for controlling the operations of traffic control signals, including the timing mechanism and all necessary auxiliary equipment, mounted in a cabinet.

(2) Flashing Operations. All controllers shall be equipped for flashing operation of signal lights. Flashing operations, when required by railroad pre-emption, flashing control, or other causes, shall be set for flashing yellow lights on the main street or highway and for flashing red on the cross street or streets, unless otherwise specified, or directed by the engineer.

(3) Railroad Pre-emption Equipment. Such equipment shall be constructed and wired to isolate the controller and assume control of the signals. Pre-emption shall cause a "yellow" indication to be displayed prior to "flashing red" indication if actuated during "green" or "flashing yellow" intervals, unless otherwise specified. Railroad pre-emption equipment shall be installed so that internal wiring of the controller, as normally furnished by the manufacturer, is not altered.

(4) Operating Voltage. All equipment, excepting pedestrian push button, shall be designed to operate from 120 volt, 60 hertz, AC supply. Operation shall be satisfactory at voltages from 110 to 130. The voltage for pedestrian push buttons shall not exceed twelve volts.

TABLE A — COLOR AND STRIPE CODE OF WIRING

Code Letter	Circuit	Phase or Function	A.W.G. Number	Conductor Colors	Stripe
S Lights: Signal		A	14	Red, Yellow, Green	Black
		B	14	Red, Yellow, Green	White
		C	14	Red, Yellow, Green	None
D Detectors		D or Special	14	Red, Yellow, Green	Orange
		A	12	Blue	Black
		B	12	Blue	White
		C	12	Blue	None
		D or Special	12	Blue	Orange
		Common	12	White	Black
P Pedestrian Buttons		A	14 or larger	Blue	Black
		B	14 or larger	Blue	White
		C	14 or larger	Blue	None
		D	14 or larger	Blue	Orange
F Flashers		----	14 or larger	Black	None
L Lights: Street		----	10 or larger	Black	None
Sign			14 or larger	Black	None
X Service (Any)		----	14 or larger	Black	None
N Neutral—All—Circuits— (except detector and pedestrian button commons)			10 or larger	Black	None
I Interconnection			14 or larger	White	None
		Common	16 (Telephone) 14 or larger	White	None
			(120-Volt)	White	None
		Resets	16 (Telephone) 14 or larger	Orange	None
			(120-Volt)	Orange	None
Y Spare		----	14 or larger	Black	None

(5) Radio Interference Suppressors. All traffic controllers, flashers or other current interrupting devices, shall be equipped with suitable radio interference suppressors installed at the input power point. Interference suppressors shall be of a design which will minimize interference in both broadcast and aircraft frequencies, and shall provide a minimum attenuation of 50 decibels over a frequency range of 200 kilohertz to 75 megahertz when used in a connection with normal installations. The interference filters shall be hermetically sealed in a substantial metal case filled with a suitable insulating compound. Terminals shall be nickel plated, 10-24 brass studs of sufficient external length to provide space to connect two No. 8 wires, and shall be so mounted that they cannot be turned in the case. Ungrounded terminals shall be properly insulated from each other, and shall maintain a surface leakage distance of not less than one-quarter inch, between any exposed current conductor and any other metallic parts, with an insulation factor of 100-200 megohms dependent on external circuit conditions. Suppressors shall be designed for operation on 15 amperes, 125 volts, 60 hertz, single wire circuits and shall meet standards of the Underwriter's Laboratories and the Radio Manufacturers Association.

(B) Solid State Actuated Controller Equipment. All actuated control equipment shall be designed for long life and shall require minimum maintenance. It shall be capable of operating for at least one year at a time without maintenance.

The sequence of operations is shown on the plans, or covered in the special provisions.

The type of phase timing units required at each intersection requiring actuated control equipment shall be shown on the plans.

Unless otherwise specified, all actuated control equipment shall be of "solid state" construction as described herein.

(1) Components—All timing circuits shall consist entirely of solid state electronic circuitry. Vacuum or gaseous tubes shall not be used.

All switching functions shall be accomplished through the use of solid state electronic circuitry. Stepping switches shall not be used.

Solid state devices shall be used to control signal light (including pedestrian signals) circuits.

Functional operating circuits and their associated components shall be grouped in plug-in printed circuit assemblies. Each grouping of components shall have a mean time to failure of three years. Printed circuits shall be of epoxy glass with extra heavy (two ounce or better) copper track.

All components shall be amply derated with regard to heat dissipating capacity and rated voltage so that, with maximum anticipated ambient temperature and maximum applied voltage, material shortening of life or shift in values will not occur. The design life of all components for continuous operating conditions shall be not less than five years.

The controller subassemblies shall be neatly and systematically arranged to make possible thorough inspection while the controller is operating normally.

The circuit reference symbol for each component part shall be clearly marked.

(2) Power—The controller and all associated equipment shall be designed for use on 120-volt, 60-hertz, single-phase, alternating current.

(3) Cabinets and Wiring—The type of cabinet to be furnished shall be as indicated on the plans or in the specifications.

All cabinet wiring shall be neat and firm and all harness and cabinet wiring shall be laced or bound together with Ty wrap (or equivalent).

All terminals shall be numbered and identified in accordance with a cabinet wiring diagram.

Five sets of wiring diagrams shall be furnished for each cabinet. The cabinet shall be equipped with a plastic envelope to house one or more cabinet wiring diagrams.

The cabinet wiring diagrams shall show and identify the connectors for all equipment and switches, relays, flashers and solid state light bases.

The cabinet wiring diagram shall also have an intersection sketch with heads, detectors and push buttons identified and a signal sequence chart identified and related to the intersection sketch.

The following terminals, wiring and switches shall be furnished for the cabinet:

Main entrance switch for control of all power to controller and auxiliary equipment. The switch shall be a circuit breaker of sufficient size and rating for the equipment and wiring installed.

Terminal, unfused, for neutral side of power supply line.

Terminals for conductors of signal light cables; one for each signal circuit and one or more terminals for the common conductors. Internal cabinet wiring shall be placed at the top of double terminals, the bottom of the terminals shall be left free for field wiring.

Terminals for detector and pedestrian push-button cables.

Terminals for connecting cable tie points and terminations.

An electromechanical, jack-mounted flasher having sufficient circuits and a flash-rate of 50 to 60 flashes per minute. The flasher mechanism

shall be actuated by switches or remote devices as specified. It shall not run continuously.

A 120-volt, A.C. ground-type convenience double outlet shall be furnished for energization of test equipment, tools and lighting.

The police panel shall contain the following switches performing the indicated functions:

1. "On-OFF" switch. Turns power on and off to the intersection control cabinet.

2. "AUTO-FLASH" switch. In "FLASH" position, places intersection on flashing operation and keeps controller in operation.

3. Any other switches as may be called for in the special provisions.

The controller cabinet shall have mounted, in the interior thereof, an "Off-FLASH" switch, performing the following functions: The "OFF" position shall keep the normal automatic operation of the controller. The "FLASH" position shall place the intersection on flashing operation and turn the controller off. It shall not be necessary to use more than one switch to perform this operation.

Radio line filter or filters for filtering AC-lights and control power for solid state light control and controller operation.

A suitable means for filtering lightning or high voltage surges to ground for protection of the solid state components.

In multiphase controller cabinets only, a 24-inch fluorescent fixture, with lamp, mounted front top of cabinet, positioned to adequately illuminate face panels of control equipment.

Each cabinet shall have a signal indication panel which will display a green, a yellow, and a red light, for each phase. The display panel shall have a north arrow, intersection layout and street names. The panel shall also have push buttons for each detection phase to simulate an actuation at the controller location.

Each cabinet shall be provided with an air filter mounted in the door and a top-mounted thermostat controlled fan which shall have a minimum capacity of 100 cfm.

The outgoing traffic control signal circuits shall be of the same polarity as the ground side of the power supply.

The grounded side of the power supply shall be grounded to the controller in an approved manner.

When the plan sheets call for additional, future phasing, all necessary cabinet wiring, connecting cables and support bases shall be provided so that the additional phase timing units, signal load units and other necessary equipment may be simply plugged in to accomplish the additional phasing.

(4) Solid State Signal and Pedestrian Lamp Circuits—All signal lamp circuits shall be external to the controller and shall be carried in jack-connected solid state-controlled units mounted in the controller cabinet.

(a) Specifications—The signal control assembly shall consist of a base of high-grade insulating material and a separate plug-in unit containing the control circuitry for the operation of three separate signal lamp circuits.

A manually operated locking device will be provided as an integral part of the assembly to permit secure vibration-proof mounting of the control unit on the base.

The design life of all components under continuous operating conditions in their circuit applications shall not be less than 5 years.

(b) Operational Requirements — Each signal circuit shall be capable of switching 1,000 watts of tungsten lamp load at 120 volts at 60 hertz to the signal lamps.

The load shall not exceed 1,000-volt amperes when inductive loads are switched.

The signal switching function shall be controlled by outputs of ground potential from the traffic signal controller.

The entire control assembly shall operate normally in a temperature environment of between minus-30 degrees Fahrenheit and plus-185 degrees Fahrenheit with one of the three circuits operating at full load at any one time.

(c) Mechanical Requirements—The outer protection case shall not be connected to any electrical circuit and shall be grounded.

All external connections to the signal control unit shall be made to terminals provided on the base. High pressure terminals shall be provided for field signal connections. Screw terminals shall be provided for all other connections.

(d) Power Supply—Power required to operate the signal control unit may be provided by a separate power supply installed within the control cabinet.

This power supply shall have a capacity to operate a minimum of ten signal control units.

(5) Power Failure Requirements—In the event of a power failure not exceeding 0.5 second duration, the controller shall continue in cyclic operation upon resumption of power.

In the event of a power failure exceeding 0.5 second duration, or at such time as the controller is turned on, the signal operation shall be

initiated in the Vehicle Clearance Intervals of the phase timing unit or units associated with the main arterial.

(6) Signal Monitor Requirements—All actuated controllers shall be equipped with a signal monitor auxiliary unit which shall be connected to the field terminals of vehicular green, arrow or pedestrian WALK indications and which, if illuminated simultaneously, would present conflicting vehicular and pedestrian movements. In the event such conflicting indications develop, with a duration exceeding one-quarter second, the signal monitor unit, together with the necessary power relay and flash relay assemblies, shall place the controller in "emergency flashing operation" and stop timing of the controller. Once this condition has been specified by the signal monitor unit, the controller can be returned to normal operation manually.

Where a traffic signal is interconnected to railroad tracks for purposes of pre-emption, if conflicting indications are given, the monitor shall disconnect the pre-emption device and place the intersection on emergency flashing operation.

(7) Mechanical Construction—Printed circuit assemblies shall be connected and systematically arranged so that they may be readily removed without unsoldering or handling individual connections.

The controller housing shall be designed to provide convenient access to the printed circuit assemblies while the controller is operating.

The controller mechanism shall be completely enclosed in a sheet aluminum case with a suitable protective finish.

The Model Number and Serial Number shall appear on the front panel of the controller.

(8) Coordination—The controller shall be capable of coordinated operation, without modifying it internally, by the simple addition of accessory equipment to the controller cabinet.

(9) Control of Timing—Means shall be provided to stop timing functions of the controller for the purpose of adding extra intervals with auxiliary equipment.

(10) Auxiliary Equipment Control Circuit—Power necessary for the operation of auxiliary equipment shall be available in the controller cabinet.

(11) Indicator Lights—An indicator light shall be associated with each timing dial of the controller. The individual indicator lights shall be illuminated whenever the timing dial with which it is associated is in effect.

Additional indicator lights shall be associated with the Maximum Green Intervals. One light shall be illuminated at all times to clearly designate which Maximum Green dial is currently in effect.

An indicator light shall be associated with the vehicle detector circuit. The indicator shall be illuminated to indicate a vehicle call for the actuated phase. During the Vehicle Interval, and extension thereof, this indicator shall be illuminated momentarily as each approaching vehicle passes the detector.

An indicator light shall be associated with the pedestrian detector circuit. This indicator shall become illuminated upon receipt of a pedestrian actuation and shall remain illuminated until the Walk Interval is introduced into the cycle, but shall be dark until the next pedestrian actuation.

An indicator light shall be momentarily illuminated whenever the actuated phase is terminated due to the expiration of the Maximum Green Interval.

All indicator lights shall have a minimum design life of 20,000 hours at rated voltage.

(C) Semiactuated Controllers—The controller shall provide for the setting up of each interval or period by means of a positive setting on a calibrated dial. The dial shall be calibrated in seconds and shall give a clear visual indication of the length of each interval or period.

Timing dials shall be on the front of the controller. They shall be easily identifiable and it shall not be necessary to remove or change wires or contacts or to use any tools in making adjustments.

A minimum range of adjustment of the timing dials shall be as follows:

Artery Minimum Green Interval	2 to 90 seconds
Artery Pedestrian Clearance Interval	2 to 30 seconds
Artery Yellow Interval	2 to 10 seconds
Artery All Red Clearance Interval	0 to 10 seconds
Side Street Walk Interval	5 to 20 seconds
Side Street Pedestrian Clearance Interval	5 to 30 seconds
Side Street Initial Interval	5 to 30 seconds
Side Street Vehicle Interval.....	2 to 20 seconds
Side Street Maximum Green 1	20 to 120 seconds
Side Street Maximum Green*2.....	10 to 60 seconds
Side Street Yellow Interval.....	2 to 10 seconds
Side Street All Red Clearance Interval	0 to 10 seconds

*Only if called for on the plans or special provisions.

Recall switches, as described in paragraph (M) following shall be provided.

(D) Two-Phase, Fully Actuated Controller

(1) Interval sequence—The controller shall provide the following signal sequence:

Interval ²	Phase A	Phase B
1	Green—Walk ¹	Red—Don't Walk
2	Green—Don't Walk	Red—Don't Walk
3	Yellow—Don't Walk	Red—Don't Walk
4	Red—Don't Walk	Green—Walk ¹
5	Red—Don't Walk	Green—Don't Walk
6	Red—Don't Walk	Yellow—Don't Walk

¹WALK only on pedestrian push-button actuation.

²An ALL RED interval per phase shall be included.

(2) Interval Setting and Adjustment—Interval adjustments shall meet all applicable portions of paragraph (f) above.

A minimum range of adjustment of the timing dials for each phase shall be as follows:

Initial Interval	5 to 30 seconds
Vehicle Interval	2 to 20 seconds
Clearance Interval (Yellow)	2 to 10 seconds
Maximum Green	20 to 120 seconds
WALK Interval	5 to 20 seconds
Pedestrian Clearance	5 to 30 seconds
ALL RED Clearance	0 to 10 seconds

(3) Operating Requirements—The clearance period for each phase shall consist of two separately timed intervals of preset duration namely:

Yellow Interval
All Red Interval

The transfer of right of way from any street, as specified above, shall take place only after the green signal has remained on that street for at least the predetermined minimum period.

With vehicle actuation only, the minimum green interval shall consist of an Initial and one Vehicle Interval. With a pedestrian, or pedestrian and vehicle call, the minimum green shall consist of the sum of the Walk Interval, Pedestrian Clearance Interval and one Vehicle Interval. Each interval shall have its own separately adjustable timing dial.

Successive push-button actuations shall not cause extension of the pedestrian Walk Interval.

Actuation of a pedestrian push button during a Pedestrian Clearance Interval, or at any other time while the pedestrian DON'T WALK signal is being displayed, shall register the presence of said pedestrian. This actuation shall be remembered so that the pedestrian WALK indication will be accorded at the next opportunity in the normal cycle of the controller.

In the event of a registered pedestrian actuation on a selected phase with no demand for pedestrian or vehicular right of way on the opposing phase, the controller shall be capable of recycling and providing pedestrian and Pedestrian Clearance Intervals. Associated with said pedestrian intervals, the pedestrian signal indications shall be accorded in the same manner and with the same functional treatment as described in the above paragraphs.

(4) Recall Switches—A recall switch with a minimum of four positions, shall be provided for each actuated phase.

With the recall switch in the OFF position, the controller shall function normally with the right of way being transferred between streets only upon detector actuation.

With the recall switch in the second position, the effect of a single vehicle detector actuation shall be attained, causing the right of way to be automatically recalled upon the expiration of all intervals of the opposing phase.

With the recall switch in the third position, the effect of a pedestrian push button shall be attained.

With the recall switch in the fourth position, the phase shall be held in the green interval for the maximum green period.

(E) Multiphase Controller (three or more phases):

(1) General—All control equipment phase units will be classified as Type I, Type II, Type III or Type IV. These types are referred to hereinafter in these specifications and represent minimum requirements as to operation. Additional features may be provided at the option of the contractor, however, optional features shall not destroy the interchangeability between phase units as specified hereinafter. The various types of phase units required on each project shall be found either on the plans or in the special provisions.

The phase diagram on the plan or in the special provisions shall indicate the number of phase units, phase sequence and interval sequence requirements of the controller. The functional requirements for each phase unit are described hereinafter.

Each phase unit shall be provided with a switch which, upon actuation, shall disable the "memory" circuit in the phase unit. With the switch in the disabled position, a vehicle must remain within the effective area of the presence detector in order to receive the green indication. The switch may be mounted on the phase unit board, on the front panel of the unit, or may be a separate labeled switch within the control cabinet remote from the phase unit.

These specifications cover phase units with single maximum circuitry. When dual maximum is required it will be so stated in the special provisions or on the plans.

The main frame shall have sufficient openings to accommodate the phase timing units, interval sequence and phase sequence units required. If future phase requirements are listed, then the number of openings and cabinet wiring shall be in accordance with the future phase diagram, but only those phase units and signal and pedestrian light control units as required by the present phase diagram shall be furnished.

(2) Mechanical Construction.—The phase timing units, interval sequence units and phase sequence units shall be plug-in modules and equipped with printed circuit board "jack-in" connectors. The mounting frame shall be equipped with sliding ways and "jack-in" receptacles to receive the modules. Each "jack-in" unit shall be capable of being removed and replaced without unsoldering or handling individual connections.

Similar "jack-in" assemblies shall be mechanically and electrically interchangeable between controllers.

The main frame shall be constructed with module recesses to accommodate the "jack-in" modules. Blank panels shall be installed over any openings not to be put to immediate use.

The mounting frame with "jack-in" modular units and power supply shall be furnished completely enclosed in a durable sheet aluminum housing with durable finish.

(F) Main Frame With Power Supply:

(1) Mechanical and Wiring—The main frame with power supply shall be equipped with the number of openings, "jack-in" hardware and electrical fittings to accommodate present and future phasing requirements. The frame shall be equipped with sliding ways and jack connectors to receive the plug-in modules. The modules shall be positively fastened to the frame. No special tools shall be required to remove or replace individual modules.

(2) Interval Sequence Unit—The main frame shall be equipped with the number of sequence units as required by the phase diagram or necessary for concurrent timing when two or more phase timing units are simultaneously assigned the right of way on a given street.

The interval sequence unit shall: (a) determine the order of, and control the timing of, the various intervals in the individual phase timing units; (b) be equipped with all facilities for supervision of all phase timing units; (c) have an "Interval Termination" light which shall pulse momentarily as each timing interval of a phase timing unit expires, except due to operation of the Maximum Green Circuit; (d) have an indicator light which shall be momentarily illuminated whenever a phase is terminated due to the expiration of its Maximum Green Interval; and (e) contain the indicator lights that are common to all phase timing units. The individual indicator lights shall be illuminated whenever the timing dial intervals with which they are associated are in effect. When concurrent right of ways are being displayed, all interval sequence units shall be active in the manner described above.

(3) Phase Sequence Unit—The phase sequence unit shall: (a) establish and control the order and operation of the phase timing units; (b) be interchangeable between similar controllers having the identical number and order of phases and concurrent and sequential phase timing; and (c) shall be specifically designed to accomplish the number of phases, the phase order and concurrent and sequential phase operation all as indicated on the Phasing Diagram as shown on the plans or attached to the special provisions.

(4) Power Supply—The main frame shall be equipped with a regulated power supply designed to generate all DC voltages required for operation of the controller. A nominal DC shall be available externally for control purposes.

(5) Signal and Pedestrian Indication Control—The cabinet shall be equipped with plug-in solid state signal and pedestrian control units. The main frame shall be equipped with solid state devices to control the cabinet-mounted solid state units and alternately these same devices shall be capable of energizing DC relays when relays are specified in lieu of solid state control.

(6) Phase Timing Units—Each phase timing unit shall be equipped with timing dials and indicator lights necessary for providing the appropriate timing intervals and, in conjunction with the indicator lights on the interval sequence unit, visual monitoring of pedestrian and vehicle detection of the assigned phase.

The light shall be illuminated when a phase is to receive the green next.

A light shall be illuminated when right of way is assigned to a phase unit.

Vehicle Call shall become illuminated and remain illuminated when vehicle actuation is received while timing control is in any other phase unit.

Vehicle Actuation shall be illuminated momentarily in response to each vehicle actuation.

Pedestrian Call shall become illuminated upon receipt of a pedestrian actuation and shall remain illuminated until the associated WALK Interval is introduced into the cycle.

Indicator lights to indicate the timing dials in effect and interval termination are included on the interval sequence unit of the main assembly.

(7) Interval Setting and Adjustment—The controller shall provide for the setting up of each interval or period by means of a positive setting on a calibrated dial. All continuously variable dials shall be equally calibrated over their entire range.

The timing dials shall be on the front of each phase timing unit. They shall be easily identifiable, and it shall not be necessary to remove or change wires or contacts, or to use tools of any kind in making interval adjustments. The use of one dial to set the timing of more than one interval is prohibited.

The knobs for all timing dials shall be color-coded to provide easy visual identification.

(G) Types of Phase Timing Units—Type I phase timing units shall provide standard resettable timing for one intersection movement (a non-volume density module without pedestrian features).

The minimum function and range of adjustment of the timing dials on the phase timing module shall be:

Minimum Initial	5 to 30 seconds
Passage Time	2 to 20 seconds
Vehicle Clearance	2 to 10 seconds
Maximum Green	20 to 120 seconds
All Red Clearance	0 to 10 seconds

A recall switch shall be provided on the front panel of the phase timing unit.

With the phase recall switch on the first (OFF) position the phase timing unit shall function normally with the right of way being transferred to the phase timing unit only upon vehicle actuation.

With the phase recall switch in the second position the effect of a single vehicle detector shall be attained, causing the right of way to be automatically recalled to the phase.

With the recall switch in the third position a Maximum period shall be substituted for the Initial period on the phase. With the recall switch in this position, the Maximum Green dial shall provide timing for the Minimum period of the Passage Interval.

Phase timing units shall provide standard resettable timing with integral pedestrian features for one intersection movement (a nonvolume density module with pedestrian features).

The minimum function and range of adjustment of the timing dials on each Type II phase timing unit shall be as required for Type I with the following additional timing dials for pedestrian functions.

Walk 5 to 30 seconds Pedestrian Clearance 5 to 30 seconds

A recall switch shall be provided on the front panel of the phase timing unit.

With the recall switch in the first (OFF) position, the controller shall function normally with the right of way being transferred between streets only upon vehicle or pedestrian actuation.

With the phase recall switch in the second position, the effect of a single vehicle detector actuation shall be attained, causing the right of way to be automatically recalled to that phase.

With the phase recall switch in the third position the effect of a single push-button actuation shall be attained, causing the right of way to be automatically recalled for both vehicles and pedestrians to that phase.

With the phase recall switch in the fourth position, a Maximum period shall be substituted for the Minimum period on that phase and there shall be instituted a pedestrian interval during such period. With the phase recall switch in this position, the Maximum period dial shall provide timing for the Minimum period of the vehicle interval.

Type III phase timing units shall provide Variable Initial and Gap Reduction timing for one intersection movement (a volume density module without pedestrian features).

The minimum function and range of adjustment of the timing dials on each Type III phase timing unit shall be:

Minimum Initial..... 5 to 30 seconds
Passage Time..... 2 to 20 seconds
Time to Reduce to Minimum Gap..... 20 to 120 seconds
Minimum Gap 1 to 10 seconds
No. of Actuations to Give Variable Initial..... 5 to 90 actuations

Variable Initial.....	5 to 60 seconds
Vehicle Clearance.....	2 to 10 seconds
All Red Clearance.....	0 to 10 seconds
Maximum Green	20 to 120 seconds

A recall switch shall be provided on the front panel. Each position of the recall switch shall provide the same functions as the recall switch for the Type I phase timing units.

Type IV phase timing modules shall provide Variable Initial and Gap Reduction timing with integral pedestrian features for one intersection movement (a volume density module with pedestrian features).

The minimum function and range of adjustment of the timing dials on each Type IV phase timing unit shall be as required for Type III with the following additional functions:

Walk	5 to 30 seconds
Pedestrian Clearance	5 to 30 seconds

A recall switch shall be provided on the front panel of the phase timing unit. Each position of the recall switch shall provide the same functions as the recall switch for the Type II phase timing unit.

(H) Operation Requirements of Phase Timing Units:

(1) Nondensity modular phase unit - Types I and II - The clearance or change period for Types I and II units shall consist of timed intervals of preset duration, namely:

Vehicle Clearance Interval.

All Red Clearance Interval. (This interval shall be omitted when the timing dial is placed at zero.)

A phase timing unit shall be ready to transfer right of way only after the green signal has been assigned to that phase unit for at least a predetermined minimum.

For Type I and Type II with vehicle actuation only, the Minimum Green Interval shall consist of a minimum Initial and one Passage Time.

For Type II with a pedestrian, or pedestrian and vehicle call, the Minimum Green shall consist of the sum of the Walk Interval, Pedestrian Clearance Interval and one Passage Time. Each interval shall have its own timing dial.

Actuation of a vehicle detector during the Passage Time portion of the right-of-way period for the street having the right of way shall cause the right of way to remain with that street for an additional Passage Time timed from the moment of detector release.

Successive push-button actuations shall not cause extension of the pedestrian Walk Interval.

The transfer of right of way from any phase timing unit may take place immediately if there has been no actuation on that pulse timing unit for more than one Passage Time Interval prior to the actuation of one of the opposing phase timing units, subject, however, to provisions of other paragraphs in this specification.

Each vehicle crossing a detector and approaching the intersection on a green signal shall initiate one Passage Time Interval from the instant of its detector release. Should transfer of right of way occur while a Passage Time Interval is unexpired, the right of way shall be returned at the next opportunity in the cycle, without the necessity of further actuation.

Detector actuation on a phase timing unit which has the red signal shall initiate the timing of a Maximum Green Interval for the phase timing unit presently assigned the right of way at the expiration of which the right of way shall be transferred to the opposing phase timing unit or units subject to the provisions of the following paragraph.

Successive detector actuations spaced less than the Passage Time shall retain the right of way, but not for longer than the Maximum Green as set on the phase timing unit.

Actuation of a pedestrian push button during a Pedestrian Clearance Interval, or at any other time while the pedestrian DON'T WALK signal is being displayed, shall register the presence of said pedestrian. This actuation shall be remembered so that the pedestrian WALK indication will be accorded at the next assignment of right of way to the phase timing unit.

In the event of a registered pedestrian actuation on a phase timing unit with no demand for pedestrian or vehicular right of way on an opposing phase timing unit, the phase timing unit shall be capable of recycling and providing pedestrian WALK and Pedestrian Clearance Intervals. Association with said pedestrian intervals, the pedestrian signal indications shall be accorded in the same manner and with the same functional treatment as described in the above and succeeding paragraphs in this section.

A minimum and guaranteed Pedestrian Protection Period shall be a two-part period consisting of the Pedestrian Clearance Interval as set on the Pedestrian Clearance timing dial plus the time as set on the Passage Time dial.

The controller shall be equipped for optional selection of flashing or steady DON'T WALK during the pedestrian Clearance Interval. Pedestrian

Clearance intervals shall flash unless otherwise called for on the plans or in the special provisions.

During the Passage Time Interval and for the balance of the right of way and Clearance Intervals, the DON'T WALK indication shall be steady.

The Type I and II phase timing units shall both be equipped for local or remote selection of Dual Mode operation. Upon selection of Dual Mode operation, the Type I Module shall act as a nonactuated vehicular phase of a two or more phase semiactuation control system with coordination features. The Type II Timing Module shall additionally provide for concurrent semiactuated pedestrian features.

During the semiactuated mode the following operational features shall be in effect:

WALK and Vehicular Green shall be displayed concurrently during the timing of the "Minimum Initial" and while the control is in the "Rest" position waiting for the release pulse from a coordination device.

A two-part Pedestrian Protection period concurrent with the Vehicular Green shall follow the "rest" position and immediately precede the Vehicular Clearance period, consisting of the Pedestrian Clearance Interval as set on the Pedestrian Clearance Timing dial plus the time as set on the Passage Time dial.

(2) Density phase timing unit (Types III and IV) — The clearance period of Types III and IV units shall consist of timed intervals of pre-set duration, namely:

Vehicle Clearance Interval.

All Red Clearance Interval. (This interval shall be omitted when the timing dial is placed at zero.)

A phase timing unit shall be ready to transfer right of way only after the green signal has been assigned to that phase timing unit for at least a predetermined minimum green period.

For Types III and IV with vehicle actuation only, the Minimum Green Interval shall consist of a Minimum Initial and one Passage Time.

For Type IV with a pedestrian, or pedestrian and vehicle actuation, the Minimum Green shall consist of the sum of the Walk Interval, Pedestrian Clearance Interval and one Passage Time. Each interval shall have its own timing dial.

Each type III and IV phase timing unit shall provide variable Minimum Initial timing for each phase. One dial, labeled "MINIMUM INITIAL" shall time the Minimum Initial Interval whenever that phase is used. A second dial, labeled "VARIABLE INITIAL" shall set the maximum amount of Variable Minimum Initial Interval that may be used by that phase. The third dial, labeled "NUMBER OF ACTUATIONS TO GIVE VARIABLE INITIAL

SET BELOW" shall determine the number of actuations required to provide the maximum amount of Variable Minimum Initial Interval.

The actual initial interval time allotted to the phase during any cycle shall vary between the minimum and maximum values in proportion to the number of actuations received to the number required to give the absolute variable Minimum Initial.

Each phase unit shall be provided with a Passage Time dial which shall provide time for a vehicle, proceeding on the green time, to proceed from the detector to the stop line. Successive actuations shall cancel the remainder of the previous Passage Time Interval, and shall initiate a complete new passage time interval, for the vehicle which provided the actuation. Should transfer of the right of way occur while a Passage Time Interval is unexpired, the right of way shall be returned at the next opportunity in the cycle.

Each phase timing unit shall contain two dials which shall provide a time-rated reduction of the Passage Time gap based upon the length of time vehicles have waited against a red indication on any conflicting phase timing unit. One dial shall determine the minimum allowable gap or time spacing between two successive vehicles which shall be permitted to continue to extend the green indication. The second dial shall determine the amount of time a vehicle or pedestrian must wait against a red light on a conflicting phase timing unit in order to reduce the gap on the street with the green light to the minimum value. This reduction shall begin from the Passage Time Interval and shall proceed smoothly to the low allowed gap without discontinuities. When termination of right of way on all conflicting phases. This feature shall assure right of way to vehicles that may otherwise become trapped between the detector and the stop line.

Each phase timing unit shall contain a Maximum Green dial which shall set a limit on the length of time that continuous traffic on the right-of-way phase can extend the right of way for that phase after an actuation is registered for any conflicting phase. Maximum Green timing will limit the actual green to the Maximum Green dial time setting after actuation is registered on any conflicting phase.

Actuation of a pedestrian push button during a Pedestrian Clearance Interval, or at any other time while the pedestrian DON'T WALK signal is being displayed, shall register the presence of said pedestrian. This actuation shall be remembered so that the pedestrian WALK indication will be accorded at the next assignment of right of way to the phase timing unit.

In the event of a registered pedestrian actuation on a phase timing unit with no demand for pedestrian or vehicular right of way on a conflicting

phase timing unit, the phase timing unit shall be capable of recycling and providing Pedestrian and Pedestrian Clearance Intervals. Associated with said pedestrian intervals, the pedestrian signal indications shall be accorded in the same manner and with the same functional treatment as described in the above and succeeding paragraphs in this section.

The minimum and guaranteed Pedestrian Protection period shall be a two-part period consisting of the Pedestrian Clearance Interval as set on the Pedestrian Clearance timing dial plus the time as set on the Passage Time dial.

The controller shall be equipped for optional selection of Flashing or Steady DON'T WALK during the Pedestrian Clearance Interval.

During the Clearance Interval the DON'T WALK shall be steady.

The Types III and IV phase timing units shall have the same Dual Mode operation as described for the Types I and II units above.

(I) Operating Characteristics of Three-phase Control Assemblies—The normal phase rotation shall be sequential, i.e., A-B-C, C, but it shall be possible to omit any phase for which there is no demand.

A+B, B+C, and A+C vehicle overlaps shall be built into the main controller assembly. (Refer to paragraph (p) of this subsection.) In the event the second phase of an overlap is to be skipped, the controller shall display a vehicle clearance for the overlap at the conclusion of the first phase. No external equipment, except Signal Light Switching Assemblies, shall be required to provide phase overlaps. When the plans or special provisions require two-phase or special overlaps, they shall be accomplished through the use of solid state circuitry included in an auxiliary housing with connecting cable and plug or cabinet wall-mounted and permanently wired into the cabinet harness.

Right of way shall not be given to any street without actuation thereon, and in complete absence of traffic, right of way shall remain on the street where it was last assigned, both of the foregoing provisions, however, being subject to the exception that recall switches shall be provided on each phase timing unit which may be turned on if desired to cause the right of way to revert to any selected street despite the absence of traffic thereon.

The actuation of a detector or push button on any street while the right of way is on an opposing street shall, after the proper clearance period, cause the right of way to be transferred to the street from which the actuation was received.

(J) Operating Characteristics of Four-phase Control Assemblies

— The normal phase rotation shall be sequential, i.e., A-B-C-D, but it shall be possible to omit any phase for which there is no demand.

A+B+C, B+C+D, A+C+D and A+B+D vehicle overlaps shall be built into the controller. (Refer to paragraph (p) of this subsection.) The controller shall provide proper vehicle clearances in the event any phase or phases of an overlap are omitted. No external equipment, except signal light switching assemblies, shall be required to provide phase overlaps. When the plans or specifications require two-phase or special overlaps, they shall be accomplished through the use of solid state circuitry included in an auxiliary housing with connecting cable and plug. (Alternately the circuitry may be cabinet wall-mounted and permanently wired into the cabinet harness.)

The last two paragraphs of subsection I also apply to four-phase control assemblies.

(K) Multiphase Operation—For multiphase operation where phase timing units time concurrently, (as with controllers generally involving five to eight phase timing units) the operation shall be as follows:

Phase overlaps shall be built into the controller. (Refer to paragraph (m) of this subsection.) The controller shall provide proper vehicle clearances in the event any phase or phases of an overlap phase are omitted. No external equipment except signal light switching assemblies shall be required to provide the reciprocal phase overlap indications described in paragraph (m) of this subsection. When the plans or specifications require overlaps other than generated by the controller, they shall be accomplished through the use of solid state circuitry included in an auxiliary housing with the connecting cable and plug. Alternately the circuit may be cabinet wall-mounted and permanently wired into the cabinet harness.

The actuation of a detector on any phase timing unit, while the right of way is on a conflicting phase timing unit, shall, after the proper Clearance Interval, cause the right of way to be transferred to the phase timing unit from which the actuation was received, subject to provisions in the operating characteristics of the phase timing units involved.

For either street, the controller shall be capable of assigning the right of way to any single phase timing unit, or any combination of nonconflicting phase timing units. If a call, or calls, exist for the other street, the controller shall assign the right of way for the first street in accordance with the established preferential phase rotation, i.e., leading turns. If no calls exist on the other street the controller shall be capable of answering any calls for any phase timing unit until such time as a call, or calls, is received for the second street.

When transferring the right of way to a street, the right of way shall only be accorded to phase timing units that have actuations. In the event only one movement requires the right of way, all other phase timing units for that street shall continue displaying red indications. Then, a call on either nonconflicting phase timing unit shall result in immediate assignment of right of way to that movement.

When, for one street, the phase timing unit controlling one through movement is in effect with a call for the other through movement or the other through movement also in effect, the first of these phase timing units assigned the right of way shall not be permitted to leave the Passage Interval until the second phase timing unit has reached its Passage Interval. While waiting for the second phase timing unit to reach its Passage Interval, the first phase timing unit shall time its Initial Interval and respond to vehicle actuations during its Passage Interval. If a gap in excess of the allowed gap occurs prior to the second phase timing unit reaching its Passage Interval, the first phase timing unit shall continue monitoring gaps and, if actuations on that approach become spaced within the allowed gap, it shall continue to extend the right of way once the second phase timing unit reaches its Passage Interval.

When transferring from any combination of phase timing units on one street to any combination of phase timing units on the second street, both phase timing units shall yield the right of way simultaneously, regardless of which phase timing unit was last to find a gap in excess of allowable gap or to have the maximum extension terminate. The phase timing unit that first finds a gap in excess of the allowable gap shall retain the green indication until the other phase timing unit also finds a gap in excess of the allowable gap, but further detector actuation for the phase timing unit that has found an excessive gap shall not extend the green indication, subject to the provisions of the preceding paragraph.

It shall be possible to skip any phase timing unit for which no demand exists.

It shall be possible to rest in any phase timing unit or combination of nonconflicting phase timing units.

(L) Control Assemblies—All control assemblies shall be so designed that any vehicle detectors or push buttons may be connected to permit actuation by vehicles or pedestrians, respectively.

(M) Phase Timing Units—Each phase timing unit, main frame assembly and cabinet wiring shall be together equipped with and wired for the following special features:

The timing functions of the phase timing units shall be capable of being

suspended temporarily for the purpose of adding extra intervals with auxiliary equipment, without interfering with functions of the controller governed by accumulating actuations during suspension of timing. When timing is suspended, the interval shall be timed following resumption of normal operation. When timing is suspended in volume density units (Types III and IV) at the beginning of the Minimum Initial Interval, actuations of the detector or detectors on that phase shall continue to increase the Minimum Initial Interval.

Each phase timing unit shall indicate the presence or absence of stored actuations on phase timing units not assigned the right of way.

Each phase timing unit shall be equipped with a coordination (hold) circuit so that any selected phase timing unit or combination of phase timing units may be held in green until the close of the coordination circuit.

Each phase timing unit and main frame assembly shall be equipped for "force off" operation. "Force off" operation shall leave an automatic vehicle recall in the phase timing unit.

Each phase timing unit shall be equipped with reciprocal phase overlap control circuits which shall generate overlap indications in accordance with the following interval sequence:

	Reciprocal Phase
Right-of-Way Indication	
Green.....	Red
Yellow	Red
Red	Green
Red (yellow interval preceding assignment to right-of-way green).....	Yellow

Each phase timing unit shall be equipped for external control of advance through its intervals.

Each main frame assembly of five or more phases shall be equipped to permit auxiliary equipment to "call away" a phase timing unit without the placing of a "call" in a conflicting phase. The operation of a phase timing unit upon energization of the "call away" circuit shall be equivalent in all respects to the operation produced by a pedestrian or vehicle call on a conflicting phase except that there shall be no transfer of right of way to a conflicting phase unless actual vehicle or pedestrian operation occurs on such phase prior to termination of right of way of the called away phase.

Each main frame assembly of five or more phases shall be equipped with such circuitry for use with external auxiliary equipment as required.

Each main frame assembly shall be equipped with circuitry to permit

external control to omit the skipping of phase timing units as required.

Each phase timing unit and main frame assembly shall be equipped for remote control from full-actuated to non-actuated (semi-actuated) operation. (See specifications for phase timing units.)

If called for on the plans or in the special provision, each main frame assembly shall be equipped with circuitry to permit instant setting of the control to preselected yellow intervals via auxiliary equipment.

Each main frame assembly shall be equipped with circuitry to permit external control to omit the All Red Interval as required.

(N) Dual Maximum Operation—This function shall be required only for those phases specified by notes on the phase diagram, intersection drawing, or special provisions. Dual maximum operation shall be accomplished with an external auxiliary device equipped with solid state circuitry and with external timing controls with a minimum range of 20 to 120 seconds. Each dual maximum circuit shall have an independent call circuit to permit independent or group calling of the second maximum circuits.

(O) Pedestrian Actuated Controllers—Pedestrian actuated controllers may be either electromechanical or solid state construction. However, the sequence of operation and timing intervals shall be the same.

(1) Operation—In the absence of actuation, the right of way shall remain on the main thoroughfare.

The transfer of right of way from the main thoroughfare shall take place after two clearance intervals.

The actuation of the push button shall cause the right of way to be transferred to the crosswalk at the expiration of a minimum period in accordance with the interval sequence specified herein.

A pedestrian clearance interval shall be provided to follow the expiration of the pedestrian interval in accordance with the interval sequence specified herein.

Continued actuation of the pedestrian push button shall not remove the right of way from the main thoroughfare without that thoroughfare receiving its allotted time.

Continued actuation of the pedestrian push button shall not provide an extension of the pedestrian interval time.

(2) Interval timing—As a minimum requirement, the controller shall be capable of adjustments to the timing of the following phases:

Phase	Time
Main Street-Green (Don't Walk).....	2-90 seconds

Main Street-Yellow (Don't Walk).....	2-10 seconds
Main Street-Red (Don't Walk).....	0-10 seconds
Pedestrian Interval (Walk)	2-30 seconds
Pedestrian Clearance Interval (Don't Walk)	2-60 seconds

(3) **Signal color sequences**—The controller shall provide for a minimum of 5 consecutive intervals for each cycle of operation. The controller shall be delivered with the following sequence of color intervals unless otherwise specified in the special provisions:

Interval	Main Street	Crosswalks
1	Green	Don't Walk
2	Yellow	Don't Walk
3	Red	Don't Walk
4	Red	Walk
5	Red	Don't Walk

(4) **Other specifications**—All applicable portions of preceding sections shall apply.

(P) **Actuated Controller Cabinets**—Cabinets may be constructed of either die cast, sand cast or heavy sheet aluminum alloy or 14-gauge (minimum) galvanized copper-bearing sheet steel. Cabinets shall be gasketed to provide a weatherproof and dustproof seal. Doors shall be hinged to provide complete access to the interior of the cabinet. The door shall be provided with a strong well-made rustproof lock as an integral part of the door. In addition, a police panel shall be provided which will open independent of the main cabinet door. Each lock shall be provided with a minimum of two keys for each cabinet having different locks. The controller cabinet shall be of such a size as to contain all the necessary equipment required for the proper operation of the traffic signal control as shown on the plans and noted in the special provisions. The nominal dimensions of cabinets are given below. It shall be possible to remove any auxiliary equipment as may be mounted in the cabinet, such as relays, without requiring the removal of the controller equipment.

Identifying terminals shall be provided for all functions specified for pretimed controller cabinets and for actuation equipment including detectors, push buttons, pedestrian interval timers, and detector relays.

All controller cabinets containing traffic actuation equipment and/or railroad pre-emption equipment shall be provided with a cabinet fan unit with a capacity of at least 100 cfm. The fan unit shall be mounted in a tamperproof ventilated dome on the top of the cabinet. Adequate screened

ventilator openings shall be provided in the bottom of the cabinets. The fan shall be controlled by a thermostat and shall start when the cabinet's internal temperature rises to 120 degrees Fahrenheit and shall continue to operate until the temperature drops to 100 degrees Fahrenheit. The fan shall operate on 115-volt alternating current.

The cable harness between the terminal panel and controller shall be equipped with a multiterminal plug, or an adaptor cable.

All controller cabinets and control equipment shall be factory wired ready for operation. Field work will be limited to placing cabinets and equipments and the connecting of field wiring to terminal strips. Cabinets shall be mounted in accordance to details shown on the plans.

The controller shall be replaceable with a similar unit without the necessity of disconnecting and reconnecting wires leading therefrom.

The nominal outside dimensions of two-phase semiactuated and full-actuated cabinets shall be: height, 31 inches; width, 19 inches; depth, 13 inches. A hinged door shall be provided which shall include substantially the full area of the front of the cabinet. When closed, the door shall fit closely to the gasketing material, making the cabinet weather-resistant and dust-tight. The cabinet shall be pole foundation or pedestal mounted and will be indicated on the plans.

Sizes of three and more phase, full-actuated controller cabinets shall be as indicated herein or on the plans or in the special provisions. Foundations for the cabinets shall be as shown on the plans. Bolt sizes and positioning shall be verified in the field prior to pouring the foundations. Cabinet doors may open right or left in the direction shown by the arrow on the plan.

All cabinets for other control equipment as may be called for by the plans or special provisions shall conform to this subsection as applicable. The size of the cabinets shall be sufficient to house all the control equipment without crowding of such equipment. Cabinets shall be equipped with bottom screened vents and top tee-vents.

(Q) Railroad Interconnect—Where interconnection to railroad circuits is called for on the plans or in the special provisions, the railroad company will furnish a set of normally closed contacts in the railroad cabinet. The contacts are opened upon train actuation of the track circuit. The contacts are a "fail-safe" device which will cause an actuation if power to the track circuit is interrupted. Interconnection from the traffic signal cabinet to the railroad cabinet shall be installed by the contractor. The circuit conductors shall be run in underground galvanized rigid electrical conduit of the size shown on the plan. The conduit shall terminate in the

railroad cabinet at a location and in a manner to be determined by the railroad company engineer. The ends of the wire shall extend a minimum of three feet beyond the end fitting inside the railroad cabinet. All work inside the railroad cabinet will be done by railroad personnel.

Under no circumstances is the contractor to do any work in the immediate vicinity of the railroad cabinet without first notifying and receiving permission of the engineer. The engineer will obtain supervisory personnel from the railroad company. The cost of providing railroad company personnel shall be included as a part of the lump sum amount bid by the contractor.

The contractor is cautioned against placing any type of materials or equipment in the area of the tracks without due regard for proper clearance from the track.

Railroad pre-emption devices may be either electromechanical or solid state construction, in either instance the following minimum operational requirements shall be included in the design of a pre-emption device which shall be a separate piece of equipment from the normal traffic signal controller.

(1) Signal operation upon pre-emption by train—Any vehicle signal displaying the green indication shall immediately receive a yellow vehicle clearance. The yellow clearance time may be controller timed or timed by a separate timing device with a minimum limit of between 0 and 60 seconds.

Any vehicle signal displaying a yellow indication shall continue to time out the controller-set yellow time or switch to an adjustable timer separate from the controller.

All pedestrian signals shall immediately receive a "Don't Walk" indication.

If vehicle signals are in an emergency flashing operation, due to either manual or remote control devices, the signal indications shall remain flashing with the pre-emptor disconnected from the circuit.

Upon train pre-emption, a red signal indication shall always be displayed in advance of the tracks to approaching vehicles.

After the yellow vehicular clearances stated above, a flashing yellow, clearance shall be provided to the movement that crosses the tracks as shown on the plans or stated in the special provisions. The flashing yellow clearance period shall be terminated with a solid yellow clearance period prior to the indications specified during train passage position or for special sequences as shown on the plans.

The timing for the flashing yellow clearance shall be adjustable between the minimum limits of 0 to 60 seconds. The solid yellow clearance interval may be a controller set interval for that phase or a separate adjustment timer. The timer shall be adjustable between the minimum limits of 0 to 20 seconds.

Upon completion of the flashing yellow and solid yellow clearance intervals stated above, the controller shall be able to respond to traffic movements that do not direct the movements over the tracks. Such permissive movements will be shown on the plans or stated in the special provisions.

The special sequence shall be retained throughout the train passage time.

(2) Signal operation after train passage—A call for “green” and/or “Walk” shall be placed on each phase to prepare for normal operation upon completion of the train passage.

Any vehicle signal having the “green” indication shall receive a steady yellow clearance indication. Such indication shall be timed on the controller phase or on a separate adjustable timer with minimum limits of 0 to 30 seconds.

Upon timing out the yellow clearance interval stated above, the controller shall revert back to normal operation unless a special sequence is called for on the plans or in the special provisions.

(R) Guarantee—All material and equipment (except lamps) will be subject to such manufacturer’s guarantee in writing as is normal practice to so guarantee the material and equipment free from defect in material and workmanship for the normal period for such guarantees from the date such material and equipment is placed in final operation. Such written guarantee shall recite that it is enforceable either by the contractor or by the Department of Highways in consideration of the purchase of the materials and equipment. A duplicate of the original of such written guarantee, duly executed by the manufacturer or his authorized representative, shall be provided to the state prior to installation of the materials and equipment.

Lamps shall carry the manufacturer’s guarantee for rated life of the lamps.

The extent of any guarantee will not be a factor in the selection of the successful bidder on the project.

(S) Pre-Timed Controllers. These controllers shall be for the purpose of operating pre-timed traffic signal systems and shall be electro-mechanical control devices complete with all accessories and equipment necessary to perform the functions specified below:

(1) Types and Functions.**(a) Non-Expansible.**

Type XXI: Non-interconnected controller.

Type XXII: Future interconnected controller.

Type XXIII: Interconnected controller.

Type XXIV: Combined master and intersection interconnected controller.

(b) Expansible.

Type XXV: Future interconnected controller.

Type XXVI: Interconnected controller.

Type XXVII: Combined master and intersection interconnected controller.

(2) Operation. All pre-timed controllers shall be capable of operating as follows:

(a) Manually.

(b) As a pre-timed controller of the independent isolated type.

(c) As a synchronous motor-driven coordinated type for progressive timing without interconnecting circuits.

Controllers shall be either one, two, or three dial as specified. Types XXV, XXVI, or XXVII controllers shall be expansible type designed to permit the installation and operation of one to three plug-connected dial units without additional wiring or modification of the controller. Types XXII and XXV controllers shall be capable of being operated as future units in an interconnected, master controlled, flexible progressive system by the addition of easily installed auxiliary attachments. Types XXIII and XXVI controllers shall be capable of being operated as units in an interconnected, master controlled, flexible progressive system and shall have single electromechanical reset per dial unless otherwise specified. Types XXIV and XXVII controllers shall be similar to types XXIII and XXVI controllers, except that they shall be equipped with master reset supervision of the intersection controllers.

(3) Mechanism for Pre-Timed Controllers. This shall be constructed as a complete, self-contained, readily interchangeable unit arranged to swing out for inspection while in operation. All parts shall be readily accessible for maintenance or replacement. All circuits of each unit shall be terminated in a multiple contact connector. Connector and the terminal block shall be connected by a flexible cable. Conductors of the cable shall be fitted with terminals to match the terminal block and shall have identifying tags.

(a) **Motor and Dial Controller Motor.** Shall be of the self-starting synchronous type, and shall have ample torque for the requirements of the controller operation. No shaft in motor gear train, except armature spindle, shall be less than 0.125 inch diameter. No gear shall be less than 0.045 inch thick. No bearing plate shall be less than 0.0625 inch thick. All intervals in each phase shall be readily adjustable by a suitable dial on the face of the controller in steps of not to exceed one per cent of the total cycle by means of self-retaining timing keys.

(b) **Signal Contact Mechanism.** All parts of the contact mechanism for signal lights, including contacts and contact supports, shall operate 1,000,000 times without mechanical wear that impairs normal operation. All signal light contact points shall be of fine silver or silver alloy not less than five-sixteenth inch diameter, of not less than ten-ampere capacity, capable of operating 1,000,000 times without excessive burning or pitting, and shall be easily removed and replaced. Cam or drum assembly shall provide not less than twelve intervals, all necessary contacts, and provisions for not less than 15 signal light contacts. Wiring shall be complete to terminal strip from each contact position.

(4) **Auxiliary Equipment.** All pre-timed controllers shall be equipped with indicating switches and wiring to provide local control of the following functions:

(a) Transfer from automatic to manual operation and vice versa.

(b) Transfer from normal operation to flashing and vice versa.

(c) Transfer from one dial to another (multidial or expansible controllers only).

(d) Turn off signal lights only (without shutting down timer mechanism).

(e) Shut down timer mechanism.

Combined master and intersection controllers shall have indicating switches for functions (2) and (3) above for the interconnected systems. Switch for local control of function (3) is not required at the master. Combined master and intersection controllers shall also have provisions for time switch control of functions (2) and (3) above for the interconnected system. Interconnected controllers shall have provisions for remote control of functions (2) and (3) above. Non-interconnected controllers shall have provisions for local time switch control of functions (2) and (3) above. All pre-timed controllers shall be wired and furnished with plug-in-mounted flashing and jack-mounted relays to permit combination of flashing red or yellow lights, or both and shall conform to Article M-310.07(A)(2). All pre-timed controllers shall be provided with hand switch

and cord set for manual operation of signals. A readily accessible mounting panel shall be furnished in each pre-timed controller cabinet, with adequate provisions for terminating all field circuits and for mounting fuses and relays. Each power and inter-connect circuit (except neutrals) shall be fused.

• **(5) Special Auxiliary Equipment.** The special equipment listed below shall be furnished and installed when specified or shown on the plans: Time switches to control system or local flash, dial change, or other specified functions. Time switch shall be synchronous motor driven equipped with ten-hour spring wound reserve carry-over, omitting device and three openings and closings per 24-hour period. Mechanical and electrical characteristics shall be equal to those specified for "Mechanism for Pre-time Controllers" above.

(6) Railroad Pre-Emption. Such relays, when required, shall perform the operations specified in Article M-310.07(A)(4).

(7) Housing for Pre-Timed Controllers. The controller shall be enclosed in a weatherproof metal cabinet of the type regularly supplied by the manufacturer, unless otherwise specified. Cabinet shall be fitted with a master-keyed, police lock and shall be mounted on a pedestal, as shown on the plans. Two keys, with shanks at least $1\frac{3}{4}$ inch long, shall be furnished for each controller. Cabinet shall be fitted with slipfitter attachment to permit post-top mounting on a 4 inch standard pipe pedestal. Screened raintight vents, $1\frac{1}{2}$ inch or larger, shall be furnished and installed on top and the lower backside of the controller cabinet.

M-310.08 TRAFFIC SIGNALS AND APPURTENANCES.

(A) Signal Heads. Each signal head shall be of the adjustable, colored light, vertical type with the number and type of lights detailed herein, and as shown on the plans; shall provide a light indication in one direction only; shall be adjustable through 360 degrees about a vertical axis; and shall be mounted as and where shown on the plans. Unless otherwise shown on the plans, all signal heads shall be standard and shall contain three lights arranged: red—top; yellow—center; green—bottom. Pedestrian signals shall be either the gas tube type or the incandescent type as specified and shall be installed where shown on the plans. All signal heads at one intersection shall be of the same make and type.

(1) Optical Units. The optical unit shall consist of a lens, a reflector, a lamp holder, and a 120 volt, clear, 6,000 hour life, traffic signal lamp, visible to the traffic to be controlled, at all distances from 10 feet to 500

feet, under all light and traffic conditions except dense fog. Lamps shall be 116 watt for eight inch lenses and 150 watt for 12 inch lenses.

Lenses shall be the color indicated, circular in shape, with a visible diameter of approximately eight inches, and of such design as to give an outward and downward distribution of light with a minimum above the horizontal. Each lens shall be true to color, of best quality glass, free from imperfections, of high illumination transmission, and shall meet latest specifications of the Institute of Traffic Engineers.

Each reflector shall consist of a one-piece, best quality, clear glass parabolical reflector, free from bubbles and striae. The confex surface shall be silvered by chemical deposition to such thickness that the lighted filament of a 150-watt incandescent lamp will not be visible through the silver layer. The silvered surface shall be protected by an additional coating of electrolytically deposited copper. An opening in the back of the reflector for the lamp holder shall be so constructed that there will be no dark spots cast on the lens. The lamp holder shall be of weatherproof mounted construction, immune to the operating temperatures of the unit, of the vibration proof type, and shall be substantially supported independent of the reflector. It shall be provided with two wires of sufficient length to be connected to the terminal block specified below. Each reflector, lens and hood shall be designed in such a manner as to reduce sunphantom to a minimum.

(2) Housing. The signal head housing, or case, shall consist of an assembly of separate sections, expansible type for vertical mounting, substantially secured together in a water-tight manner to form a unit of pleasing appearance. Each section shall house an individual optical unit. Each section shall be complete with a one-piece hinged door, mounting for the lens and the other parts of the optical system, watertight gaskets, and a simple, non-corrodible door-locking device. The optical system shall be mounted so the various parts may be swung open for ready access or removal. The sections shall be interchangeable and so constructed that sections can be removed or added. There shall be a round opening in the bottom and top of each head to receive a 1½ inch supporting pipe frame. All parts of the housing, including the doors and end plates, shall be of die cast anodized aluminum conforming to ASTM B 85, and all parts shall be clean, smooth, and free from flaws, cracks, blow holes, or other imperfections. All parts such as hinge pins, lens clips, locking devices, and the like, shall be made of non-corrodible material.

A terminal block of an approved type shall be mounted inside at the back of the housing. All sockets shall be so wired that a white wire will be

connected to the shell of the socket and a black wire to the bottom, or end terminal, of the socket. These wires shall, in turn, be connected to the terminal block, mounted in the housing, in the proper manner.

The terminal block shall have sufficient studs to terminate all field wires and lamp wires independently, to the block, with separate screws. The terminals to which field wires are attached shall be permanently identified to facilitate field work. Where terminal compartment is used, terminal block in associated heads may be omitted.

Each lens shall be protected with a removable tunnel hood of 0.030 inch thick sheet anodized aluminum open at the bottom and 8 inches long (unless otherwise specified) and so designed as to prevent a false indication to traffic not intended to be controlled by that particular signal face. The inside surface of all hoods shall be painted a flat black to prevent reflection.

(B) Directional Louvers. Where shown on the plans, louvers shall be furnished and installed in signal hoods. Directional louvers shall be so constructed as to have a snug fit in the signal hoods. The outside cylinder shall be constructed of Gage 22 sheet steel and the vanes shall be constructed of Gage 27 sheet steel. Dimensions and arrangements of vanes shall be as shown on plans. Louvers shall be galvanized in conformance with ASTM A-153, and painted with two coats of weather resistant flat black enamel.

(C) Back Plates. Where shown on the plans, back plates shall be furnished and attached to the signal heads. Back plates shall be constructed of anodized, 3-S, half-hard, aluminum sheet, 0.058 inch minimum thickness, and of the dimensions shown on the plans. Back plates shall be painted as specified in Article 87.07.

(D) Mounting Brackets. Bracket mounted signal heads, as shown on the plans, shall be supported by mounting brackets consisting of assemblies of 1½ inch standard steel pipe and malleable iron or brass pipe fittings. All members shall be either plumb or level, symmetrically arranged, and securely assembled. Construction shall be such that all conductors are concealed within poles and assembly. At each signal location, unless shown otherwise on the plans, a terminal compartment shall be constructed into the mounting brackets, as detailed on the plans. For post-top mounting of bracket-mounted signals the terminal compartment shall be cast with an integral slip-fitter. For post-top mounting of a one-way signal head a slip-fitter without a terminal compartment may be used. Slip-fitter shall fit over a 4 inch standard pipe. Each slip-fitter shall be provided with two rows of set screws with three screws in each row to

secure assembly in plumb position. Set screws shall be cadmium plated. Where signal heads are mounted on luminaires or other tall poles, the compartment shall be designed to bolt or clamp securely to the pole. Each compartment shall be fitted with a terminal block containing twelve terminals, each with two pressure type connectors. Each connector shall accommodate at least five No. 14 conductors. A raintight cover shall be provided giving ready access to the terminal block. Terminal compartment shall be of non-frangible metal containing not less than 60 per cent copper and shall be of sufficient strength to remain intact in event the pole is knocked down. Slip-fitters, where used without integral terminal compartments, shall be of cast iron or copper-bearing metal as specified for terminal compartments.

(E) Signal Head Mounting. Signal heads shall be equipped with positive lock rings and fittings designed to prevent heads from turning due to external forces. Lock ring and connecting fittings shall have serrated contacts as shown on the plans. Signal head assembly for suspension from mast arm shall be equipped with an internally wired plumbing device.

(F) Installing Signal Heads. Signal heads shall not be installed at an intersection until all other signal equipment, including the controller, is in place and ready for operation at that intersection, except that the signal heads may be mounted if the faces are not directed toward traffic or if the faces are covered.

(G) Pedestrian Signals. Pedestrian signals shall be rectangular in shape and shall contain the lettered messages **WALK** and **DON'T WALK**. The design and construction of the **DON'T WALK** signal shall be such that, in the case of an electrical or mechanical failure of the word **DON'T**, the word **WALK** will also remain dark. All pedestrian signals within one intersection shall be of the same approved type. Relays for the operation of **DON'T WALK-WALK** signals shall be placed in the controller cabinet.

Type 1—Gas-Filled Forming Tubing. The letters shall be at least 4½ inches high and shall be in two lines. The **WALK** indication shall be lunar white, and the **DON'T WALK** indication shall be Portland orange. Housing shall be a one piece aluminum alloy casting. Transformers, wiring, and terminal blocks for field connections shall be located in the rear compartment. Both front and rear compartments shall be dustproof.

Type 2—Incandescent. The letters shall be at least three inches high. The **WALK** and **DON'T WALK** signals shall be in separate signal sections. The **WALK** lens shall be lunar white glass meeting the latest standards of the Institute of Traffic Engineers with all except the letters obscured by an

opaque material. The **DON'T WALK** lens shall be orange glass meeting the latest standards of the IT of E with all except the letters obscured by an opaque material. The aluminum reflector shall be mounted in a cast aluminum housing.

Signals shall be made weathertight by means of moulded neoprene gaskets between all component parts.

Lamps shall be traffic signal type, 120 volt, 116 watt, clear, 6000-hour life.

M-310.09 DETECTORS AND PUSH BUTTONS.

(A) **Magnetic Detectors.** These shall consume no power, and shall contain no moving parts. They shall not be rendered inoperative or continuously operated by parked cars or other fixed iron objects such as road reinforcement, water or gas pipes, and the like, which may be within their zone of influence. Extremes of temperature or humidity shall not affect proper operation of magnetic detector equipment. Magnetic detectors shall be moisture-proof and capable of withstanding all soil conditions without impairing their efficiency. All coils shall be water-proofed by the vacuum impregnation process. Magnetic detectors shall have sufficient mechanical strength to withstand the transmitted shock of traffic without damage.

(1) **Directional Magnetic Vehicle Detector.** A detector having two magnetic circuits shall be considered to be a compensated detector under the terms of this specification. The magnetic material and coil assemblies shall consist of an integral unit assembly for placing in position in the roadway.

Detectors of the compensated type shall be so designed and constructed that they will not be actuated by external magnetic fields caused by currents or current changes in adjacent electrical conductors such as street car tracks or feeders, power cables, and the like. The compensated magnetic detector shall have a sharply defined zone of influence, which shall be substantially the same as its over-all length. The compensated magnetic detector shall detect cars which pass through its zone of influence at speeds up to 60 m.p.h. only in a direction towards the intersection. The detector shall be designed to permit balancing of any non-symmetrical magnetic disturbances caused by road-reinforcing, pipes, manholes, and the like, in the direct vicinity of the detector. This design shall be of such nature as to allow adjustment of the discrimination of the detector for vehicles traveling over the detector in the reverse direction against those in the forward direction. The compensated

magnetic detector shall have an internal resistance not to exceed 3,500 ohms and shall be designed for operation with magnetic detector relays of the vacuum tube amplifier type. The elements of the detector shall be suitably housed for mechanical protection. Each compensated magnetic detector shall be provided with a suitable means for making a closed conduit system with provisions for a splicing chamber at the road surface.

(2) Magnetic Vehicle Detector Relays. These shall be of the vacuum tube amplifier type. The input circuit shall have an impedance greater than 75,000 ohms. Any contact which opens or closes in response to vehicle actuation shall be capable of making, breaking and carrying three amperes at 155 volts, A.C. The sensitivity of the magnetic vehicle detector relay shall be adjustable from the front of the case by means of a knob. Magnetic detector relays shall be designed for operation on a 115-volt, 60 hertz A.C. supply. Maximum power consumption shall not exceed 15 watts. The magnetic detector relay shall be suitably enclosed in a protective and durably finished sheet metal case. The overall dimensions shall not exceed 4 inches x 10 $\frac{1}{4}$ inches x 5 inches (optional 8 inches x 6 inches x 5 inches). It shall be supplied for plug connection.

(B) Loop Detector Installations.

(1) Loop Detectors. Loop detectors shall be installed where and as shown on the plans. A piece of wood should be used to seat the loop wire in the channel and care taken **NOT** to injure the wire insulation. One continuous length of No. 12 copper wire with four-sixty-fourths inch thick type UF insulation shall be used, with the specified number of turns, to form the loop. The lead in portion of the loop wire, from the loop to the adjacent pull box, shall be twisted three turns per foot and run through one-half inch rigid steel conduit to the pull box. Soldered and watertight splices shall be used in the pull boxes adjacent to loops.

(2) Loop Detector Amplifier. The intent of this specification is to describe a completely self-contained electronic unit for detecting the passage or presence of vehicles by means of a wire loop embedded in the roadway surface.

The loop detector amplifier shall be a solid state device with integral regulated power supply.

Total wire loop detection area capacity of the detector shall be up to 300 square feet. From one to six roadway loops (operating into a common traffic phase of a signal controller) shall be usable with a single detector unit.

Interconnect cable between the loop detector pull box and the ampli-

fier unit in the controller shall consist of two AWG No. 20 stranded copper conductors with polyethylene insulation, twisted, with an overall tinned-copper shield and vinyl jacket, rated 250 volts.

Interconnect runs of up to 450' shall be usable depending on size of the roadway loop.

Paired detector units shall be usable, with appropriate discriminating relay equipment, for directional detection.

Single-lane detection accuracy of the detector shall be within plus or minus two percent of the actual count.

Detection shall be positive for all speeds between 0 and 80 miles per hour.

Detection shall be positive for all classes of vehicles from motorcycles to tractor-trailer combinations.

Three modes of detection operation—"Pulse", "Medium Term Presence and Long Term Presence", shall be provided. Selection of operational mode shall be by means of a switch in the front panel of the detector unit and shall not require circuit changes, substitutions, modifications or additions.

In the "Pulse" mode of operation, the detector unit shall produce a fixed-length impulse output signal for each vehicle entering the loop. If a vehicle stops within the loop, its entrance into the loop shall be detected and produce an actuation. Subsequent vehicles passing over the unoccupied position of the loop shall also be detected.

In the "Medium Term Presence" mode of operation, the detector unit shall produce an actuation directly proportional in duration to the loop size and speed and length of the passing vehicle. If a vehicle stops within the loop the detection signal shall persist so long as the stopped vehicle is in the loop, up to a maximum time period of one minute. After one minute, the vehicle stopped within the loop shall no longer be detected, and further vehicles passing over the unoccupied portion of the loop shall be detected.

In the "Long Term Presence" mode of operation, the detector unit shall produce an actuation directly proportional in duration to the loop size and speed and length of the passing vehicle. If a vehicle stops within the loop the detection signal shall persist so long as the stopped vehicle is in the loop, up to a maximum time period of ten minutes. After ten minutes the vehicle stopped within the loop shall not be detected any longer and further vehicles passing over the unoccupied portion of the loop shall be detected.

The registration of overlapping impulses from two detector units connected to one counter or one phase of a traffic signal controller shall be

insured by the use of normally open and normally closed contacts of the out-put relay.

Field tuning of the detector unit to the roadway embedded loop shall be accomplished by means of a tuning knob and indicator light on the front panel of the detector unit. Tuning shall not require a meter and shall not require any circuit changes, substitutions, modifications or additions to the detector unit.

Field adjustment of detection sensitivity of the roadway loop shall be accomplished by means of a sensitivity adjustment knob and indicator light on the front panel of the detector unit.

Sensitivity adjustment shall not require a meter and shall not require any circuit changes, substitutions, modifications or additions to the detector unit. Sensitivity adjustment range shall be adequate to provide positive detection with loops installed on heavily reinforced roadways.

The front panel indicator light used for tuning and sensitivity adjustment shall also serve as an operation indicator and illuminate as each vehicle actuation is registered.

Operating frequency range of the detector shall be 75 to 195 KC.

The units shall operate from 115 volt 60 hertz power line and shall draw a maximum of 15 watts.

Operation of the detector shall be independent of power line variations between the limits of 90 to 140 volts and temperature variations between the limits of -40° and 170° F.

An automatic frequency control feature and automatic equalization feature shall be included in the detector to compensate for long-term phase drift due to environmental changes and component aging.

In the event of a momentary power failure, proper operation of the detector shall commence immediately upon restoration of power without the creation of false calls or the loss of information produced prior to the loss of power.

The detector shall contain an integral regulated power supply for maximum flexibility of application.

No vacuum tubes shall be used. Temperature compensated circuits, utilizing silicon planar transistors and silicon diodes shall be provided. An open-type printed circuit board shall be used. The printed circuit board shall be of epoxy glass with extra heavy (two oz. or better) copper track.

The output relay shall be plug-mounted and shall be normally energized so as to provide fail-safe operation in the event of a circuit failure.

The detector shall be suitably fused. The fuse shall be readily replaceable without the use of tools from the front of the detector.

The detector shall be housed in a durably finished fabricated sheet

aluminum case. Maximum dimensions of the case shall not exceed 3 in. x 6 in. x 10⁵/₈ in.

No special tools shall be required for removal of the cover. Removal of the cover shall provide access to the entire circuit and all components while the unit is connected and operating.

Electrical connections of both the incoming and outgoing circuits shall be made by means of a ten terminal MS type plug. The detector unit shall be replaceable with a similar unit without the necessity of disconnecting and reconnecting individual wires leading therefrom. The Type MS plug shall be of protected male construction and rigidly fixed to the front of the unit. The mating MS plug receptacle shall be attached to one end of a connecting cable at least 24 inches long. The other end of the connecting cable shall have tagged leads, each of which shall be fitted with a spade type lug for easy attachment to terminal blocks.

(C) Pedestrian Push Buttons. Where shown on the plans, pedestrian push buttons of substantial tamper-proof construction shall be furnished and installed. They shall consist of direct push button and a single momentary contact switch in a cast metal housing on which shall be attached the push button sign shown on the plans. The switch shall have snap action contacts actuated by a three-bladed beryllium copper spring and shall be rated ten amperes, 125 volts.

The assembly shall be weatherproof and so constructed that it will be impossible to receive any electrical shock under any weather condition. The housing shall be shaped to fit the curvature of the pole to which it is attached, to provide a rigid installation. Saddles shall be provided to make a near fit, when required, Push button and sign shall be installed on the crosswalk side of the pole.

M-310.10 LIGHTING AND OTHER SYSTEMS

(A) Luminaires. Types and styles of luminaires, lamp equipment and transformers shall be as specified in the special provisions or as shown on the plans. All side and end mounted luminaires shall be equipped with two inch slip-fitter.

(B) Flashing Beacons. Where shown on the plans, flashing beacons shall be installed. Beacon shall be a single unit signal head, meeting the requirements of the provisions of Article M-310.08(A) with yellow or red lens as shown on the plans. Mounting of beacon shall be as shown on the plans. Flasher shall be motor driven or an electronic device without tubes. Contacts shall be silver or silver alloy not less than three-eighths inch diameter rated at 20 amperes, 115 volts. Flasher shall provide 50 to 60 flashes per

minute, with equal on and off intervals, and shall be equipped with a radio interference suppressor, as specified for traffic signal controllers. Workmanship and materials shall be equal to that specified for controllers. Flasher shall be encased in a rain-tight housing. When flashing beacons are installed adjacent to or in conjunction with a traffic signal system, the flasher control shall be installed in the controller cabinet unless otherwise shown on the plans.

(C) Sign Lighting Fixtures. These shall be as shown on the plans, or as specified.

(D) Fluorescent Sign Lighting Fixtures. These shall be as detailed on the plans. Fixtures shall be rain and dust tight with 1 or 2 72T12 CW/HO tubes and integral 800MA ballast providing minus 20° F. starting capacity.

(E) Photo-Electric Controls.

(1) Types. These as specified or shown on the plans, shall be one of the following types, and shall be capable of switching multiple lighting systems directly or of switching series lighting systems through a high voltage controller:

Type I shall consist of a photo-electric unit and a contactor in a single weather proof housing.

Type II shall consist of a photo-electric unit in a weather proof housing and a separate contactor located in a traffic signal controller cabinet.

Type III shall consist of a photo-electric unit and a separate contactor, both in weatherproof housings. A switch to permit manual operation of the contactor shall be provided. Switch shall be furnished with an indicating nameplate reading "Auto-Off-Manual" with "OFF" in the center position.

(2) Equipment Details.

(a) Photo-Electrical Unit. The photo-electric unit shall consist of a light sensitive element connected to control relay, either directly or through a vacuum tube amplifier. The light-sensitive element shall have a spectral response such that it is especially sensitive to north sky illumination and shall have an "on" level adjustment between minimum limits of one and five foot-candles. The units shall be so designed that a failure of an electronic component will energize the lighting circuit. A time delay shall be incorporated into the unit to prevent operation in the event of brief changes in lighting conditions. The photo-electric unit shall be mounted at the top of the standard designated on the plans and shall be oriented as ordered by the engineer.

(b) Contactor. The contactor shall have contacts rated to switch

the specified lighting load and shall be normally open unless otherwise specified. It shall be either the mechanical armature type (indicated by subscript "-a") or mercury-tube type (indicated by subscript "-m") as specified or shown on the plans. The mechanical armature shall consist of an operating coil, a laminated core, a laminated armature, contacts and terminals. Contacts shall be silver alloy. The mercury-tube type shall consist of an operating coil, necessary mercury tubes and terminals. Mercury tubes shall be hermetically sealed and shall contain an inert gas. Contact shall be made either mercury to mercury or between mercury and contacts of an alloy resistant to both arcing and mercury amalgamation.

(c) Contactor Housing. When located externally, the contactor shall be housed in either a suitable NEMA Type 3 rain-tight enclosure with dead front panel and hasp for padlock or in a traffic signal controller cabinet. The rain-tight enclosure shall be mounted on the same standard as the photo-electric unit at a height of approximately 8 feet above the base.

(d) Wiring. Conductors between the photo-electric unit and an external contactor shall be No. 14 AWG and shall be run inside the lighting standard.

(F) Isolating Transformers and Ballasts. Type and style of isolating transformers shall be as specified or as shown on the plans. They shall be equipped with non-hygroscopic leads and shall be sealed to insure satisfactory operation under continuous submersion in water. Splices at transformers shall conform to Article 87.06. Where more than one conductor enters a transformer sleeve the insulation and taping shall be applied between the conductors in such a manner as to provide a water-tight joint. The splice installation shall be capable of satisfactory operation under continuous submersion in water. When connecting mercury vapor ballasts to multiple circuits, the primary circuit at each ballast shall be connected to the tap nearest the actual line voltage. The voltage shall be measured when all lamps and other loads on the circuit are energized.

M-310.11 OVERHEAD CONDUCTOR LIGHTING INSTALLATION.

(A) Equipment.

(1) Luminaire. Luminaire shall be as specified on the plans. Light source shall be a high intensity discharge type; mercury vapor, low or high pressure sodium vapor. Light distribution shall conform to the Illuminating Engineering Society (IES) type as specified. Luminaires shall be designed

weatherproof and for ease of maintenance. The luminaire shall include integral ballast and lamp.

Ballasts shall be integral with luminaire and shall provide minus 20° F. starting capacity. Multiple ballasts shall be 115/230 volts constant wattage type, 0.97 power factor, holding lamp wattage to plus or minus three percent of rated voltage with fluctuation of voltage to plus or minus 15 volts at 115 volts and plus or minus 30 volts at 230 volts.

Series ballasts shall be designed for 6.6 amp constant current service and have 0.88 power factor.

(2) Lighting Brackets. These shall be constructed to the dimensions as shown on the plans. All brackets shall exceed NEMA and IES standards as to vertical and horizontal deflection. Bracket wiring between luminaire and ballast secondary shall be No. 10 AWG copper, insulated for 600 volts.

(3) Wood Poles For Highway Lighting. Wood poles shall conform to ANSI specifications for wood poles except that a line drawn from the center of the pole at the ground to the center of the pole at the top shall lie within the body of the pole. Poles shall be machine peeled. Poles shall be set to the depths recommended by the ANSI specifications. Poles shall be set truly plumb and in line, and shall be thoroughly and firmly tamped. Effort shall be made to keep from damaging the finished surface of the pole and any injury thereof shall be repaired to the satisfaction of the engineer. The following treatments will be used as specified on the plans or special provisions:

(a) Treated poles shall receive full length pressure treatment with a five percent by weight pentachlorophenol solution or Copper Chromate Arsenate (CCA) type B or C, or Ammoniacal Chromate Arsenate (ACA) conforming to AWPA standards and the requirements of Section M-270.

(b) Painted poles shall have standard incised butt penta treatment per AWPA specifications. Pole shall receive two coats of black paint, conforming to Article M-280.02 (9) from below ground line to a point two feet above the ground line. The remainder of the pole above ground shall receive one coat of primer and two coats of aluminum paint, conforming to Article M-280.02(3).

(4) Steel Poles for Highway Lighting. Construction and installation shall conform to the provisions of Articles 87.06 and M-310.04 of the plans and special provisions.

(B) Line Material

(1) All hardware shall be as described on the plans, or herein, shall be suitable for the use intended, and shall be galvanized. Hardware shall be installed with lock-nuts, tightly drawn up in a manner to cause the least radio interference.

(2) Insulators for brackets, clevises and upset bolts shall possess characteristics as follows: wet process type, overall dimensions three inch diameter x 3 3/16 in., 5/8 in. bolt hole, 7/16 in. radius wire slot, vertical mounting, wet flashover 14 KV, horizontal mounting wet flashover 17 KV, dry flashover 26 KV, and ultimate mechanical strength 5,000 pounds.

(3) Double upset bolts shall be 9/16 in. steel with 5/8 in. rolled threads, 1 1/2 in. upset to upset, and 4 1/2 in. threaded insulator end with cotter key.

(4) Insulated brackets shall be primary spool type clevises of the cross arm mounting type. Construction shall be of 1 3/4 in. x 1/8 in. steel provided with a 3/4 in. mounting hole and 5/8 in. cotter pin for mounting the insulator mentioned in part (b) above. The clevis shall be so designed that the distance from the center of the insulator to the mounting face will be five inches.

(5) Insulated swinging clevises shall be of 1-1/2 in. x 3/16 in. steel, 5 in. from 5/8 in. cotter pin to eye attachment, for 3 in. insulator and 5/8 in. eyebolt or eyenut.

(6) Connectors shall be of proper size, material and design for the use intended. Copper-to-copper connectors shall be of high strength silicon bronze, threaded with spacer and nut; aluminum-to-copper connectors shall consist of aluminum alloy bolt and nut with plated copper spacer and plated copper contact with plating removed from contact surfaces to identify copper conductor location.

(7) Insulated tension splices shall have an insulated length of four inches, clips for attaching tap wires shall be of proper size for the wire being installed. Engineer's approval shall be secured before installation. Insulated tension splices shall be used, where required in series installations, with the following general rules:

(a) Splices shall not be located closer than 18 inches from a support point.

(b) Splices shall not be located in spans crossing a highway, street, railroad or similar condition.

(8) Overhead line conductor shall be as specified on the plans and special provisoins. Conductor with cuts, kinks or other injuries shall not be installed. On angle assemblies the conductor shall be placed on the side of the insulator away from the strain and tied in place as shown on the plans. Wire shall be sagged in the presence of the engineer, using tables provided by him. An approved thermometer shall be used for determination of the temperature. The wire shall be gradually pulled up to the required sag, taking care that the wire is free to move at intermediate support points and that the wire is not pre-stretched by pulling beyond the required sag.

(9) Guys and Anchors.

(a) Guys and anchors shall be installed where and as indicated on the plans. Two strain insulators shall be in every guy span. Eyebolts, eye-nuts, and anchor rods shall have the thimble type or eye when used on guys. When eyebolts and eyenuts are used on down guys, they shall have the 45° angle type.

(b) Guy wire shall be three-eighths inch Siemens-Martin seven strand, double galvanized with class "B" zinc coating in accordance with ASTM A-363, unless otherwise indicated on the plans.

(c) Clamp, three bolt, shall be medium duty for the purpose intended. All three bolts shall be tightly drawn up and located as shown on the plans. Devices with stainless steel bail for straight through dead ending of guy wire may be used in place of guy clamps.

(d) Guy protectors shall be 8' long, full round type of gage 14 galvanized steel.

(e) Insulator, strain, shall have the following characteristics:

Rated Voltage.....	4.4
Flashover Voltage: 60 Cy. Dry KV	30
60 Cy. Wet KV.....	15
Mechanical Strength.....	12,000
Maximum Cable Size, Inches.....	1/2
Length	4-1/8
Width.....	2-7/8

(f) Anchors and rods shall be of the size and type indicated on the plans. They shall be in line with the strain and shall be installed so approximately six inches of the rod remains out of the ground. The hole, after the anchor has been set in place, shall be backfilled with coarse crushed rock for two feet above the anchor, tamped during the filling. All anchors shall be tamped the full depth of the hole.

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NOTES

SECTION M-320

SIGNING MATERIAL

Resume' of Contents

Article M-320.01	Materials for Signs.....	640
Part (A)	Sheet Aluminum	640
Part (B)	Aluminum Sheet Increment.....	641
Part (C)	Plywood	641
Part (D)	Aluminum and Steel Posts.....	641
Part (D) (1)	General.....	641
Part (D) (2)	Steel Posts & Tubular Rail.....	641
Part (D) (3)	Aluminum Posts.....	642
Part (E)	Treated Timber Posts.....	642
Part (F)	Treated Timber Poles.....	642
Part (G)	Barn Poles	643
Part (H)	Overhead Structures.....	643
Part (I)	Concrete	643
Part (J)	Reflective Sheeting - A.....	644
Part (J) (1)	General.....	644
Part (J) (2)	Photometric.....	644
Part (J) (3)	Color.....	645
Part (J) (4)	Adhesive	645
Part (J) (5)	Film.....	646
Part (J) (6)	Assurance of Durability	646
Part (J) (7)	General Characteristics & Packaging	647
Part (K)	Reflective Sheeting - B.....	648
Part (K) (1)	General.....	648
Part (K) (2)	Photometric.....	648
Part (K) (3)	Adhesive	648
Part (K) (4)	Film.....	649
Part (K) (5)	Assurance of Durability	650
Part (K) (6)	General Characteristics & Packaging	651
Part (L)	Letters, Symbols and Accessories.....	651
Part (L) (1)	General.....	651
Part (L) (2)	Type A Letters-Acrylic Plastic Reflectors	651
Part (L) (3)	Type B Letters - Removable.....	654

Part (L) (4)	Type C Letters - Direct Applied	655
Part (M)	Paints.....	656
Part (N)	Hardware	656
Article M-320.2	Fabrication of Signs	656
Part (A)	Aluminum Signs.....	656
Part (B)	Plywood Signs.....	656
Part (C)	Letters, Symbols & Accessories	656
Part (C) (1)	Screen Processed Legend & Borders.....	657
Part (C) (2)	Permanently Adhered Reflective Legend & Borders.....	657
Part (C) (3)	Demountable Reflective Legend & Borders.....	657
Article M-320.03	Reflectorized Plastic Pavement Markers & Legends.....	657
Part (A)	Composition Requirements.....	657
Part (B)	Physical Requirements	658

M-320.01 MATERIAL FOR SIGNS.

(A) Sheet Aluminum. Sheet aluminum shall be aluminum alloy conforming to Aluminum Association alloy designation 6061-T6 (hereinafter abbreviated to AA6061-T6). The thickness of sheet material used for aluminum signs shall be as set forth in table A.

TABLE A
SINGLE POST CENTERLINE MOUNTING
Without Back Bracing

Sign Size	Metal Thickness
Regulatory Series	
Less than 20 inches wide.....	0.063 in.
21 in. to 30 in. inclusive.....	0.080 in.
31 in. to 36 in. inclusive.....	0.100 in.
37 in. to 42 in. inclusive.....	0.125 in.

Regulatory signs wider than 42 inches must be back braced with the exception of the 48 in. x 48 in. stop signs which may be made with unbraced 0.125 inch aluminum.

Warning Series

30 in. x 30 in. or smaller	0.080 in.
36 in. x 36 in.....	0.100 in.
48 in. x 48 in.....	0.125 in.

Route Marker Series

Same as regulatory series. Width dimension is taken at widest point on cut out shields.

With Back Bracing

All Sizes shall be..... 0.080

Delineator Reflectors

All Sizes shall be..... 0.063 in.

(B) Aluminum Sheet Increment. Aluminum Sheet increment signs shall be constructed of 0.125 inch thick AA 6061-T6 sheet aluminum fastened to an extruded "T" section (AA 6063-T6) backing with 3/16 in blind rivets. The extruded "T" section shall weigh at least 0.88 lbs. per linear foot and have a minimum moment of inertia about the neutral axis of 0.40 in 4.

(C) Plywood. All sign faces that are specified to be made of plywood shall be constructed of overlay, high density Douglas fir plywood conforming to the requirements as set forth in "Commercial Standard 45 for Douglas Fir Plywood". The plywood shall be B-B high density overlay, 60/60 with amber overlay both sides and of thickness three-quarter inch or as shown on the plans.

(D) Aluminum and Steel Posts and Rails.

(1) General. The size and shape, including any holes or cuts shall conform to applicable standard drawings, and special provisions. In steel posts, when holes or cuts are made in the field, the bared areas shall be given one coat of metal primer and two coats of Aluminum paint. Galvanized posts shall be treated in accordance with ASTM A-123 (AASHTO M-111).

(2) Steel Posts and Tubular Rail.

(a) Steel Structural. Steel structural posts having a nominal weight of more than three pounds per linear foot shall conform to ASTM A-36. These will be bid as "steel structural sign posts."

(b) Steel U Sign. Steel posts formed into a "flying U" shape, having a nominal weight of three pounds or less per foot, shall conform to Commercial standard 184 as published by the U.S. Department of Commerce. These will be bid as "steel U sign posts."

(c) Tubular Steel Posts. Round tubular steel posts shall conform to ASTM A-53 Type E or S - Grade B. Square or rectangular tubular posts shall conform to ASTM A-500 or A-501. The contractor may elect to use

either painted or galvanized posts. Galvanized posts shall conform to the galvanizing requirements of ASTM A-123. Posts to be painted shall not be galvanized but shall be painted with a shop coat (primer) and a first field coat meeting the requirements of Article M-280.02(6) or (7) and one coat of aluminum paint meeting the requirements of Article M-280.02(3). All paint applications shall conform to the applicable requirements of Section 91.

(3) Aluminum Posts.

These posts shall conform to ASTM B-209 and shall be extruded from 6061-T6 alloy to form a U channel design.

(E) Treated Timber Posts. All treated timber posts shall be of construction grade, S4S, and full pressure treated with a five percent by weight pentachlorophenol solution or Copper Chromate Arsenate (CCA) type B or C, or Ammoniacal Chromate Arsenate (ACA) conforming to AWWA standards, and in accordance with the requirements of Section M-270. All cutting, trimming and boring shall be done prior to treatment. Treatment shall result in a uniform color between posts as well as along the length of an individual post.

All posts for each project shall be uniform in color. Inspection will be made at the place of treatment.

The manufacturer, at his option, may attempt to secure a uniform color by treating all timber required for each project simultaneously in one process, steam cleaning the posts after processing or by the use of one carrier for treating all batches of posts for each project.

When posts have been damaged or when it becomes necessary to cut or bore into pieces after treatment, injuries, cuts or holes shall be poured full of, or swabbed with, two applications of hot preservative or a concentrated solution of CCA (type B or C) or ACA conforming to AWWA standard.

The contractor may, at his option, cut posts to length and bore the necessary holes in the field. All posts cut or bored in the field will receive preservative treatment as set forth above.

(F) Treated Timber Poles. All treated timber poles shall conform to A.S.A. specifications and dimensions and shall be the species listed in group IV, V or VI. All poles on any one project shall be of the same species. All poles shall be machine peeled and full length pressure treated with a five percent by weight pentachlorophenol solution of CCA (type B or C) or ACA in accordance with Section M-270. Each pole shall be gained on the sign face a minimum width of two inches. Poles may be gained full-length but the minimum length shall be the top half of the pole.

Backbracing, where required, shall be pressure treated, construction

grade, 2 in. x 4 in. S4S. Backbracing will not be paid for directly but shall be considered incidental to and absorbed in payment for the other items of the contract.

All cutting, trimming and boring shall be done prior to treatment. When poles have been damaged or when it becomes necessary to cut or bore into pieces after treatment injuries, cuts or holes shall be poured full of, or swabbed with, two applications of hot preservative or a concentrated solution of CCA (type B or C) or ACA conforming to AWP standards.

The contractor may, at his option, cut treated timber poles to required lengths and bore necessary holes in the field. All cuts and borings will be treated with preservative as set forth above.

(G) Barn Poles. Barn Poles are specified according to top diameter. These will be in the nominal diameters 3 in., 4 in., 5 in., and 6 in. The following list is the top diameter limits for the nominal top diameter.

Nominal Top Diameter	Limits
3 in. top = diameter of at least 3 in. but not as large as 4 in.	
4 in. top = diameter of at least 4 in. but not as large as 5 in.	
5 in. top = diameter of at least 5 in. but not as large as 6 in.	
6 in. top = diameter of at least 6 in. but not as large as 7 in.	

All poles shall comply with ASA specification for straightness. Barn poles shall be full-length pressure-treated in accordance with Section M-270.

The contractor may cut treated timber poles to the required lengths and bore necessary holes in the field.

When poles have been damaged or when it becomes necessary to cut or bore into pieces after treatment, injuries, cuts or holes shall be poured full of, or swabbed with, two applications of hot preservative or a concentrated solution of CCA (type B or C) or ACA conforming to AWP standards. Each pole shall be gained on the sign face a minimum width of two inches. Poles may be gained full-length but the minimum length shall be the top half of the pole.

Backbracing, where required, shall be pressure treated, construction grade, 2 in. x 4 in. S4S. Backbracing will not be paid for directly but shall be considered incidental to and absorbed in payment for the other items of the contract.

(H) Overhead Structures. Overhead sign structures shall meet the requirements of the details shown on the plans and specified in the contract.

(I) Concrete. Concrete for steel sign post foundations shall be class "A"

or "D", conforming to Section 40. Concrete may be mixed in approved transit mixers. No hand mixing will be allowed. An air-entraining agent shall be added to all concrete in the foundations.

(J) Reflective Sheeting—A.

(1) General. The reflective sheeting shall consist of spherical lens elements embedded within a transparent plastic having a smooth, flat outer surface. The sheeting shall be weather resistant and have a protected precoated adhesive backing.

(2) Photometric.

(a) Background. The reflective sheeting shall have the following minimum brightness values at 0.2° and 0.5° and 1.5° divergence expressed as average candlepower per foot-candle per square foot of material. Measurements shall be conducted in accordance with standard testing procedures for reflex-reflectors of Federal Specification L-S-300. "Sheeting and Tape, Reflective; Nonexposed Lens Adhesive Backing", para. 4.5.2.9 or as amended.

	Silver-White #1			Silver-White #2			Yellow		
	0.2°	0.5°	1.5°	0.2°	0.5°	1.5°	0.2°	0.5°	1.5°
Div. Ang.									
Inc. Ang.									
— 4°	60.0	25.0	4.0	72.0	33.0	4.0	30.0	15.0	2.5
40°	12.5	7.5	1.6	14.0	10.0	1.6	6.0	4.0	0.9
	Red			Blue			Green		
	0.2°	0.5°	1.5°	0.2°	0.5°	1.5°	0.2°	0.5°	1.5°
Div. Ang.									
Inc. Ang.									
— 4°	12.5	6.5	1.0	4.0	2.0	0.6	9.0	4.5	1.0
40°	1.9	1.2	0.4	0.9	0.4	0.08	1.8	1.0	0.2
	Orange								
	0.2°	0.5°	1.5°						
Div. Ang.									
Inc. Ang.									
— 4°	14.0	8.0	1.3						
40°	2.0	1.5	0.3						

(b) Applied or Demountable Copy. Reflective sheeting for all sign copy including letters, numerals, symbols, borders, and route markers shall be Silver-White No. 2. Encapsulated lens, wide angle reflective sheeting may be used when specified in the plans. See Section M-320 part (k).

(c) **Rainfall Performance.** The brightness of the reflective sheeting, totally wet by rain, shall not be less than 90% of the above values. Wet performance measurements shall be conducted in conformance with Standard RAINFALL TEST specified in Federal Specification L-S-300B, "Sheeting and Tape, Reflective, Nonexposed Lens Adhesive Backing".

(3) **Color.**

(a) **Color Tolerance** - The diffuse day color of the reflective sheeting shall conform to the "Color Tolerance Charts for Standard Highway Sign Colors" published by the U.S. Department of Transportation, Federal Highway Administration, Washington, D.C. The charts referred to are: for Highway Yellow (PR Color No. 1), Highway Red (PR Color No. 2), Highway Blue (PR Color No. 3), Highway Green (PR Color No. 4), Highway Brown (PR Color No. 5), and for Highway Orange (PR Color No. 6).

(b) **Silver-White** - The diffuse day color of Silver-White No. 1 and Silver-White No. 2 reflective sheeting shall conform to the following requirements and shall be determined in accordance with ASTM-E-97-55 (reference ASTM-E 308).

CIE CHROMATICITY COORDINATE LIMITS

(1)		(2)		(3)		(4)		Reflective Limit	Munsell Paper Ref. Std.
x	y	x	y	x	y	x	y		
.320	.310	.360	.360	.338	.377	.300	.328	34.0 Minimum	5. 1GY 6.91/1.2

(4) **Adhesive.**

(a) The reflective sheeting shall include a pre-coated pressure sensitive adhesive (Type I) or a tack-free heat activated adhesive (Type II), either of which may be applied without necessity of additional adhesive coats on the reflective sheeting or application surface.

(b) The protective liner attached to the adhesive shall be removed by peeling without soaking in water or other solvents and shall be easily removed after accelerated storage for four hours at 150° F. under weight of 2.5 pounds per square inch.

(c) The adhesive shall form a durable bond to smooth, corrosion and weather-resistant surfaces and permit the reflective sheeting to adhere securely 48 hours after application, at temperatures of —30° to 200° F. The adhesive bond shall be sufficient to render the applied sheeting vandal-resistant and prevent its shocking off when jabbed with a spatula at —10° F. The sheeting shall resist peeling from the application surface when a 5 lb/in. width force is applied as outlined in ASTM-D-903-49.

(5) Film.

(a) **General.** The reflective sheeting shall have sufficient strength and flexibility so that it can be handled, processed and applied according to the recommendations of the sheeting manufacturer without appreciable stretching, tearing, or other damage. It shall permit application over and conformance to moderate, shallow embossing characteristic of certain sign borders and symbols. Following liner removal, the reflective sheeting shall not shrink more than one-thirty second inch in ten minutes nor more than one-eighth inch in 24 hours in any dimension per nine inch square at 72° F. and 50% RH.

The sheeting when applied according to manufacturer's recommendations to cleaned and etched 0.020" x 2" x 8" aluminum, conditioned (24 hours) and tested at 72° F. and 50% RH shall be sufficiently flexible to show no cracking when bent around a three-quarter inch mandrel.

(b) **Surface.** The sheeting surface shall be smooth and flat, facilitate cleaning and wet performance, and exhibit 85 glossmeter rating of not less than 40 (ASTM-D-523-62T). The sheeting surface shall be readily processed and compatible with recommended transparent and opaque process colors and show no loss of the color coat with normal handling, cutting, and application.

The sheeting shall permit cutting and color processing at temperatures of 60-100° F. and relative humidities of 20-80%. The sheeting shall be heat resistant and permit force curing without staining of unapplied sheeting at temperatures up to 150° F. and up to 200° F. on applied sheeting. The sheeting surface shall be solvent resistant such that it may be cleaned with gasoline, VM&P Naphtha, mineral spirits, turpentine, methanol and xylol.

(c) **Lens Elements.** The reflective sheeting shall possess stable and durable spherical lens elements which, following extraction, shall show no deterioration following submersion in a 5N solution of sulphuric acid (H_2SO_4) for 30 minutes at 72° F.

(6) Assurance of Durability.

(a) The contractor shall install reflective sheeting according to the manufacturer's recommendations. The contractor shall also certify that the reflective sheeting used for each project will meet or exceed the requirements of the following table.

Sheeting Type & Color	Average minimum candlepower per foot candle per square foot at 0.2° divergence and —4° incidence	Satisfactory Performance Life
Silver-White #1	30	7 Years
Silver-White #2	36	7 Years
Yellow	12	7 Years
Red	5	6 Years
Blue	2	7 Years
Green	3	7 Years
Orange	7	5 Years

Candle power measurement shall be made, following sign cleaning, in accordance with procedures recommended by the sheeting manufacturer or the reflective material exposed at a commercial test facility for 24 months in Florida at 45° south facing, shall not support fungus growth and accumulate dirt to the extent that the reflective brightness before cleaning is less than 75% of the reflective brightness after cleaning, when measured at 0.2° divergence and —4° incidence. The supplier shall furnish written evidence or samples showing conformance to this requirement.

(b) The sheeting surface may be readily refurbished by cleaning and clear over-coating in accordance with the manufacturer's recommendations.

(7) General Characteristics and Packaging. The reflective sheeting as supplied shall be of good appearance, free from ragged edges, cracks, and extraneous materials, and shall be furnished in both rolls and sheets. When the reflective sheeting is furnished in continuous rolls, the average number of splices shall not be more than three per 50 yards of material with a maximum of four splices in any 50 yard length. Splices shall be butted or over-lapped and shall be suitable for continuous application as supplied.

Rolls shall be packed snugly in corrugated fiberboard boxes in such manner that no damage or defacement may occur to the reflective sheeting during shipment or storage.

Rolls three inches in width to twelve inches in width shall be packed in corrugated fiberboard cartons of minimum 200 test. Rolls 13 inches width to 24 inches in width shall be packed in corrugated fiberboard cartons of 275 test. Rolls 25 inches in width and above shall be packed in corrugated cartons of minimum 350 test. Rolls wider than six inches and ten yards in length or longer shall be supported and suspended by the roll core within dispenser type boxes by means of metal plugs adhered to and within built-

up and reinforced corrugated pads. Rolls shall be protected with creased traps of corrugated board.

Cut sheets shall be packaged flat between pressed composition board or corrugated pads of the same dimensions to prevent damage or defacement during shipment or storage.

Stored under normal conditions reflective sheeting shall be used for signing fabrication within a period of 18 months from the date of manufacture.

(K) Reflective Sheeting—B

(1) **General.** The reflective sheeting shall consist of spherical lens elements adhered to a synthetic resin and encapsulated by a flexible, transparent, weatherproof plastic having a smooth outer surface. The sheeting shall have a protected pre-coated adhesive backing. The color of the reflective sheeting shall be as specified.

(2) **Photometric.** The reflective sheeting shall have the following minimum brightness values at 0.2°, 0.5° and 1.5° divergence expressed as average candle-power per foot-candle per square foot of material. Measurements shall be conducted in accordance with standard photometric testing procedures for reflex-reflectors, paragraph 4.5, 2.9 of Federal Specification L-S-300B, "Sheeting and Tape, Reflective; Non-exposed Lens Adhesive Backing".

Divergence Angle	Silver			Green		
	0.2°	0.5°	1.5°	0.2°	0.5°	1.5°
Incidence Angle						
—4°	180	65	8	30	10	0.6
40°	25	15	2	4	2	0.2

Wet performance measurements on unweathered sheeting shall be conducted in accordance with standard rainfall test specified in Federal Specification L-S-300B and the brightness of the reflective sheeting totally wet by rain shall not be less than 90 percent of the above values or samples shall be submerged in a tank of clean water (approximately 72° F.) for a period of five minutes. Reflex-reflective performance of the sheeting shall be viewed in a darkened room by reflected light through the surface of the water or through a transparent plane surface of the tank parallel to the sample surface. Light source shall be such as a hand flashlight held close to the eye. The wet sheeting shall show no apparent loss of reflective performance as compared to dry material.

(3) Adhesive.

(a) The reflective sheeting shall include a pre-coated pressure

sensitive adhesive and shall be applied in a manner specified by the sheeting manufacturer to recommended, properly prepared flat surfaces without necessity of additional adhesive coats on the reflective sheeting or application surface.

(b) The protective liner attached to the adhesive shall be removed by peeling without soaking in water or other solvents and shall be easily removed after accelerated storage for four hours at 150° F. under weight of 2.5 pounds per square inch.

(c) The adhesive shall form a durable bond to smooth corrosion and weather resistant surfaces and permit the reflective sheeting to adhere securely 48 hours after application at temperatures of —10° F. to 150° F. The adhesive coated sheeting shall be vandal resistant and when jabbed with a spatula at —10° F. the adhesive bond shall prevent the reflective sheeting from shocking off. The sheeting shall resist peeling from the application surface when a five lb./in. width force is applied as outlined in ASTM-D-903-49.

(4) Film.

(a) **General.** The reflective sheeting shall be sufficiently flexible to be easily cut to shape. Following liner removal, the reflective sheeting shall not shrink more than one sixty-fourth inch in 24 hours in any dimension per nine inch square at 75° F. and 50% RH.

The sheeting when applied according to manufacturer's recommendations to cleaned and etched 0.020 inch x 2 inch x 8 inch aluminum, conditioned (24 hours) and tested at 72° F. and 50% RH shall be sufficiently flexible to show no cracking when bent around a three-quarter inch mandrel.

B) Surface. The sheeting surface shall be smooth and facilitate cleaning and wet performance, and exhibit 85% gloss meter rating of not less than 50 (ASTM-D-523-62T). The sheeting surface shall be readily processed and compatible with recommended transparent and opaque process colors and show no loss of the color coat with normal handling, cutting and application. Following accelerated outdoor exposure as outlined in part five of this specification, no process colors shall be removed when tested by scratching through the color surface, applying cellophane tape over the scratched area, and removing the tape with one quick motion.

The sheeting shall permit cutting and color processing at temperatures of 60° - 100° F. and relative humidities of 20 - 80%. The sheeting surface

shall be solvent resistant such that it may be cleaned with gasoline, VM&P Naphtha, mineral spirits, turpentine, and xylol.

(c) **Cleanability.** The reflective sheeting shall be easily cleaned and shall show no appreciable loss of reflective intensity or change in appearance when compared with new material. A sample shall be applied in accordance with the manufacturer's recommendations to a 6 inch x 12 inch 0.040 aluminum panel. The sample shall be thoroughly hand cleaned with non-abrasive detergent, rinsed, and wiped dry. The sample shall then be sprayed with water suspended soils collected from the underside of local vehicles and allowed to dry thoroughly.

The water suspension of soils shall be prepared by scraping dirt, and the like, from the underside of vehicle fenders, mixing with water in the proportion of five pounds of soil to one gallon of water, and pouring the mixture through a paint strainer to remove large particles. Mixture shall then be vigorously stirred and then immediately sprayed onto panel while particles are in suspension. After the panel is thoroughly dry, it shall be washed with a clean mixture of water and a mild detergent. Panel shall be cleaned, clear water rinsed, and wiped dry for examination.

(5) Assurance of Durability.

(a) The contractor shall install reflective sheeting according to the manufacturer's recommendations. The contractor shall also certify that the reflective sheeting used for each project will meet or exceed the requirements of the following table.

Sheeting Type and Color	Average minimum candlepower per foot candle per square foot at 0.2° divergence and —4° incidence	Satisfactory Performance Life
Silver	120	7 Years
Green	20	7 Years

(b) When mounted on flat degreased and etched aluminum panels the reflective sheeting shall be weather resistant and following cleaning shall show no appreciable discoloration, cracking, blistering, chalking, or dimensional change and not less than 80% of the specified minimum brightness values wet or dry when exposed to outdoor accelerated weathering for two years south facing, unprotected at 45° in south Florida.

(c) The reflective sheeting exposed at a commercial test facility for 24 months in Florida at 45° south facing, shall not support fungus growth and accumulate dirt to the extent that the reflective brightness, before

cleaning, is less than 75% of the reflective brightness after cleaning, when measured at 0.2° divergence and -4° incidence. The supplier shall furnish written evidence or samples showing conformance to this requirement.

(6) General Characteristics and Packaging. The reflective sheeting as supplied shall be of good appearance, free from ragged edges, cracks, and extraneous materials, and shall be furnished in both rolls and sheets. There shall be no more than 4 splices per 50 yard length and splices shall be suitable for continuous application as supplied.

Rolls shall be packed snugly in corrugated fiberboard boxes in such manner that no damage or defacement may occur to the reflective sheeting during shipment or storage.

Rolls three inches in width to 12 inches in width shall be packed in corrugated fiberboard cartons of minimum 200 lb. test. Rolls 13 inches in width to 24 inches in width shall be packed in corrugated fiberboard cartons of 275 lb. test. Rolls 25 inches in width and above shall be packed in corrugated fiberboard cartons of minimum 350 lb. test. Rolls wider than six inches and ten yards in length or longer shall be supported and suspended by the roll core within dispenser type boxes by means of metal plugs adhered to and within built-up and reinforced corrugated pads. Rolls shall be protected with creased traps or corrugated board.

Cut sheets shall be packaged flat between pressed composition boards or corrugated pads of the same dimensions as the sheets and shall be so packed as to prevent damage or defacement during shipment or storage.

Stored under normal conditions reflective sheeting shall be used for signing fabrication within a period of 18 months from the date of manufacture.

(L) Letters, Symbols and Accessories.

(1) General. These materials shall be the type specified by the plans. Type A, type B or type C, as described in following parts, will be used.

(2) Type A Letters-Acrylic Plastic Reflectors.

(a) Description. Cutout letters, numerals, alphabet accessories and border strips shall consist of embossed aluminum frames in which prismatic reflectors are installed so as to be an integral part of the character, or otherwise securely affixed to the aluminum frame so as to prevent their displacement in handling or service. Letters which utilize tape to hold reflectors in place are not acceptable.

(b) **Design and Fabrication.** Letter design shall be the Federal Standard Alphabet Series "D" or "E" modified to accommodate the required reflectors. Letters, numerals, borders and accessories shall be constructed of 0.040 inch thick sheet aluminum. Sufficient mounting holes shall be provided in the frame to permit the use of screws, rivets, or other common fasteners. The size and spacing of the reflector buttons shall be such as to afford maximum night legibility and visibility to the finished cutout figure.

(c) **Finishing of Frames.** After the metal fabrication has been completed, the aluminum shall be degreased, etched, neutralized and treated so as to insure adherence of enamel paint. After treating, the frames shall be finished in the color specified on the plans with good quality metal enamel in strict accordance with the paint manufacturer's recommendations.

(d) **Acrylic Plastic Reflector.**

(1) **Manufacture.** The reflectors shall consist of a transparent acrylic plastic face, (herein referred to as the lens) and an opaque plastic back of like material fused to the lens under heat and pressure around the entire perimeter to form a unit permanently sealed against dust, water, and water vapor. The reflector lens shall be colorless, yellow, or as specified on the plans.

The lens shall consist of a smooth front surface free from projections or indentations other than for identification or orientation and a rear surface bearing a prismatic configuration such that it will effect total internal reflection of light. The manufacturer's trade mark shall be molded legibly into the face of the lens.

(2) **Optical Requirements.** The following definitions are established for the purpose of testing optical performance, as designated herein. "Entrance Angle" shall mean the angle at reflector between direction of light incident on it and direction of reflector axis. "Observation Angle" shall mean the angle at reflector between observer's line of sight and direction of light incident on the reflector. "Specific Brightness" shall mean candlepower returned at the chosen observation angle by a reflector per square inch of reflecting surface for each foot candle of illumination at the reflector.

The specific brightness of each reflector intended for use in cutout letters, symbols and accessories shall be equal to or exceed the following minimum values with measurements made with reflectors spinning. Failure to meet the specific brightness minimum shall constitute failure of

the reflector being tested; failure of more than two reflectors out of fifty subjected to test shall constitute failure of the lot.

Observation Angle Minutes	Entrance Angle Degrees	Specific Brightness Candlepower/Square Inch/Foot-Candle
6	0°	14.0
6	20°	5.6

For yellow reflectors, the specific brightness minimum shall be 60 percent of the value shown for crystal.

(3) Testing Procedure. The reflex reflector to be tested shall be located at a distance of 100 feet from a single uniformly bright light source having an effective diameter of 2 inches; the light source shall be operated at approximately normal efficiency. The return light from the reflector shall be measured by means of a photo-electric photometer having a minimum sensitivity of 1 x 10⁻⁷-foot candles per mm scale division.

The photometer shall have a receiver aperture 0.5 inch diameter, shielded to eliminate stray light. The distance from light source center to aperture shall be 2.1 inch for a 6 minute observation angle, 3.5 inch for a 10 minute angle, and 6.9 inch for a 20 minute observation angle. During testing the reflectors shall be spun so as to average orientation effect.

If a test distance other than 100 feet is used, the source and aperture dimensions and the distance between source and aperture shall be modified in the same proportion as the test distance,

(4) Durability. The following test shall be used to determine if a reflector is adequately sealed against dust and water: Submerge 50 samples in water at room temperature. Subject the submerged samples to a vacuum of five inches gage for five minutes. Restore atmosphere pressure and leave sample submerged for five minutes, then examine the samples for water intake. Failure of more than 4 per cent of the number tested shall be cause for rejection.

(5) Sampling Procedure. For qualification purposes only, the 50 samples required for all the tests set forth in this specification may be submitted by the manufacturer. For acceptance purposes, the 50 samples will be selected at random by the purchaser from each shipment. Sample lot and acceptance practice will be the same regardless of the size of the shipment, unless specified otherwise.

(6) **Packaging.** Each cutout figure, completely assembled with reflectors, shall be supplied in an individual package with contents marked thereon.

(3) Type B Letters—Removable.

(a) **General Description.** The silver-white letters, numerals, symbols and borders shall be of adhesive coated reflective sheeting permanently adhered to embossed aluminum backing.

The reflective sheeting shall be Silver-White No. 2 having the properties given in part (J) of this specification or if called for in the plans it shall be of the Encapsulated type having the properties given in Part (K) of this specification.

Letter and number design shall conform to Part (L) (2) (b).

(b) **Photometric.** The reflective sheeting shall have the same brightness properties as specified in part (J) or Part (K) of this specification.

The brightness of the reflective sheeting, totally wet by rain, shall not be less than 90 percent of the above values. Wet performance measurements shall be conducted in conformance with standard rainfall test specified in Federal Specification L-S-300B.

(c) **Color.** Diffuse color requirements shall conform to Part (J) (3) for silver-white No. 2 or Part (K) (2) Silver as appropriate.

(d) **Adhesive.** Adhesive qualities shall conform to Part (J) (4) or Part (K) (3) as appropriate.

(e) **Durability.** Durability shall conform to Part (J) (6) or Part (K) (5) as appropriate.

(f) **Fabrication.** The reflective sheeting shall be mechanically applied to the properly prepared aluminum with the equipment and in a manner prescribed by the sheeting manufacturer.

Letters, numerals and symbols shall be 0.040 inch thick aluminum sheet of 3003 H14 alloy; borders shall be 0.032 inch thick aluminum sheet of 6061 T6 alloy. Aluminum shall be properly degreased and etched or treated with a light, tight amorphous chromate type coating and all units shall have an embossed height of approximately 1/8 inch.

Spacing of mounting holes for screws, bolts, or rivets shall be determined by the character, size and shape and, in no case, shall be more than 8 inches on center.

Completed demountable letters, numerals, symbols and borders shall be edge sealed with a sealer as specified and supplied by the sheeting manufacturer.

(g) **General Characteristics and Packaging.** The finished letters, numerals, symbols and borders shall show careful workmanship and be clean cut, sharp and have essentially a plane surface.

The manufacturer shall certify that all letters, numerals, symbols and borders furnished conform to this specification and will replace or repair without cost all which fail to meet those requirements.

Letters, numerals, symbols and borders shall be packaged in such a manner as to insure their arrival at destination in undamaged condition. Materials which become wet in storage or shipment will be rejected.

(4) Type C Letters—Direct Applied

(a) **Sheeting.** The silver white, letters, numerals, symbols and borders shall be of adhesive coated reflective sheeting permanently adhered to the reflective sheeting on the sign face. They shall be cut out of silver white No. 2 or if specified in the plans, out of silver, encapsulated sheeting.

(b) **Photometric.** The reflective sheeting shall have the brightness properties as specified in Part (J) or Part (K) of this specifications as appropriate.

(c) **Color.** Diffuse color requirements shall conform to Part (J) (3) for silver No. 2 or if encapsulated sheeting is specified in the plans it shall be silver conforming to Part (K) (3).

(d) **Adhesive.** Adhesive qualities shall conform to Part (J) (4) or Part (K) (3) as appropriate.

(e) **Durability.** Durability shall conform to Part (J) (6) or Part (K) (5) as appropriate.

(f) **Fabrication.** The reflective sheeting letters, symbols, numerals and borders shall be applied in strict conformance to the manufacturer's instructions.

The size, series and spacings shall be as shown in the plan sheets or standard drawings as appropriate.

(g) **General Characteristics and Packaging.** The finished letters, numerals, symbols and borders shall show careful workmanship and be clean cut.

They shall be packaged in accordance with the packaging instructions found in Parts (J), (K) and (L) of this specification. If shipped pre-cut they shall be packaged in such a manner as to arrive undamaged. Material that becomes wet in shipment or storage will be rejected.

(M) **Paints.** All paints shall conform to the provisions of Section M-280 unless otherwise specified.

(N) **Hardware.** Bolts, washers, nuts and lock washers used for erecting aluminum sheet and plywood signs shall be: Galvanized steel, galvanized in accordance with ASTM A-153 or A-164; Cadmium plated steel, plated in accordance with ASTM A-165; Aluminum Alloy conforming to ASTM B-211, alloy 2024-T4.

When steel bolts and aluminum sheets are used a neoprene washer shall be used between the head and the aluminum sheet and between the sheet and the nut.

M-320.02 FABRICATION OF SIGNS.

All signs shall be fabricated by skilled workmen and shall show careful workmanship.

(A) **Aluminum Signs.** All aluminum signs shall have reflectorized background. Reflective sheeting shall be applied to the sign face in complete conformance with the recommendations of the manufacturer of the reflective sheeting used.

Following application of the reflective sheeting, all edges shall be sealed with an edge sealer recommended by the manufacturer of the reflective sheeting used.

Heads of the blind rivets will be colored to match the sign face. Background material shall be applied to the sheet aluminum prior to the fabrication of the sign. Sheet increments shall be butted snugly together to insure a neat, well appearing joint.

(B) **Plywood Signs.** All plywood signs shall have a reflective background, unless otherwise specified. All edges, including interior joints, shall be sealed using one coat of exterior aluminum paint followed by one coat of air-drying enamel with a color closely matching the color of the reflectorized background. The reflective sheeting shall be applied to the surface in complete conformance with the recommendations of the manufacturer of the reflective sheeting used.

Following application of the reflective sheeting all edges shall be sealed with an edge sealer recommended by the manufacturer of the reflective sheeting.

(C) **Letters, Symbols and Accessories.** The Federal Highway Administration standard alphabets and spacing shall be used on all signs erected.

(1) Screen Processed Legend and Borders. Legend and border on reflectorized backgrounds shall be screen processed or reverse screened. The recommendations of the manufacturer of the reflective sheeting shall be followed in the use of process paints.

(2) Permanently Adhered Reflective Legend and Borders. Legend and border shall be cut from reflective sheeting that meets the requirements of Section (K) (3) (a) through (e).

Letters shall not be spliced. Application of letters shall be in complete conformance with recommendations of the manufacturer of the reflective sheeting used.

(3) Demountable Reflective Legend and Borders. Demountable legend shall be in conformance with the provisions of Article 320.01 (L) (3). Letters shall not be spliced and demountable borders and median sections shall be maximum lengths whenever possible. All joints shall be butted snugly together and not overlapped.

M-320.03 REFLECTORIZED PLASTIC PAVEMENT MARKERS AND LEGENDS.

(A) Composition Requirements:

The reflective plastic marker material, hereafter referred to as plastic shall consist of:

	(Comparison by Weight)	
	Maximum	Minimum
1) Plastics and Plasticizers	46%	40%
2) Pigments	42%	38%
3) Graded Glass Spheres	18%	14%

Pigments shall include titanium dioxide for white markers and C.P. medium chrome yellow for yellow markers. This titanium dioxide should be at least 20 percent of the total pigment in white markers. The yellow markers should have a minimum of 18 percent pigment as chrome yellow. The graded glass spheres shall be colorless, clean and transparent, free from miliness. The spheres when tested by the liquid immersion method at 25° C., shall show an index of refraction within the range of 1.50 to 1.60. A minimum of 85 percent of the glass spheres shall be retained on a 140 mesh U.S. Standard Screen, when tested in accordance with A.S.T.M. Method of Test D-1214-54, "Method of Test for Sieve Analysis of Glass Sphere".

(B) Physical Requirements:

(1) **Bend Test:** The plastic shall be of such a structure that at a temperature of 80° F., a piece three inches x six inches (with backing) placed upon a one inch diameter mandrel may be bent over the mandrel until the end faces are parallel and one inch apart. There shall be no fracture lines apparent in the uppermost surface by visual inspection.

(2) **Reseal Test:** The plastic shall reseal to itself when tested as specified. Cut two, one inch x three inch pieces of plastic. Overlap these pieces face to face for an area of one sq. in. on a flat steel plate with the backing material remaining in place. Center a 1000 gram weight over the 1 sq. in. overlap area, and place in an oven at 190° ± 10° F. for two hours. After cooling to room temperature, the pieces shall not be separable without tearing.

(3) **Adhesive Backing Release Material Removal:** The release material shall be completely removed when tested as specified. Cut a one half inch x six inch specimen. Remove the release material for one inch of the length and attach the non-adhesive side to a vertical surface with a suitable clamp at the point where the release material was removed. Attach a clamp which has a supported one lb. weight attached to it, to the end of the partly removed release material. Release the weight. Examine the specimen for any remaining release material. There shall be no failure or tearing of the protective paper during removal of the paper from any sample.

(4) **Strength:** The plastic shall require between 10-25 lbs. to break. The elongation shall be no greater than 50 percent. The specimens for this test shall be Type I prepared in accordance to the methods described in A.S.T.M. Designation (D-638-61T). One inch squares of carborundum extra coarse emery cloth or its equivalent, may be applied at each end of the test specimens to prevent the plastic adhesive from adhering to the test equipment. The break resistance shall be based on an average of at least 3 samples. The rate of pull of the test shall be 0.25 of an inch per minute. This test shall be conducted at a temperature of 70°-80° F.

(5) **Plastic Pull Test:** A test specimen cut to dimension of one inch x six inch shall support a dead load weight of six lbs. for not less than 30 minutes. This test shall be conducted at a temperature of 70°-80° F.

(6) **Glass Sphere Retention:** The plastic shall have glass sphere retention qualities. A two inch x six inch specimen of plastic shall be cut at a right angle to the wide beveled edge and bent parallel to the beveled edge on a one-half inch mandrel. While the specimen is bent, a strip of one-half inch wide masking tape (such as Utilitape, manufactured by

Permacel) shall be applied firmly along the length of the area of maximum bend and then removed. Should any glass spheres remain on the masking tape when the strip is removed, the sample shall be rejected.

(7) **Skid Resistance.** The surface friction properties of the plastic shall not be less than 35 BPN when tested according to A.S.T.M. Designation E-303-66T.

(8) **Abrasion Resistance:** The plastic marker shall have a maximum loss in weight of 0.25 grams in 500 revolutions when abraded according to Fed. Test Method Standard No. 141a (Method 6192), using H-18 calabrade wheels with 1000 gram load on each wheel.

(9) **Lateral Shock Load Test:** A three inch x six inch plastic panel shall be applied to a three inch x six inch piece of carborundum extra coarse emery cloth, or its equivalent, so that three inch x three inch overlap occurs. The application shall be such that a pressure of 50 p.s.i. is placed on the panel for 30 seconds. The overlap ends shall each be clamped and with one end in a fixed position, a sudden load of 50 lbs. shall be applied vertically to the other end. Upon immediate load release and examination, there shall be no noticeable slipping or fracture of the adhesive coating. This test shall be conducted at 70⁰-80⁰ F.

(10) **Adhesive Stability Test:** The pre-coated adhesive backing shall be pressure-sensitive and shall remain stable with controlled degree of flexibility and flow. The same specimen as described above shall withstand a static load of 4 lbs. for a period of 30 minutes, similar to the description of the testing in A.S.T.M. D 816-61T, Method "B". The slippage between the plastic panel and the emery cloth shall not exceed 1 inch. This test shall be conducted at 70⁰-80⁰ F.

(11) **Adhesive Shear Strength:** Specimens shall be tested according to the method described in A.S.T.M. D 638-61T as modified to test the adhesive shear strength. The samples shall be prepared as follows: Plastic samples cut as described in Paragraph (e) above, shall have applied to the adhesive face a one inch x three inch piece of carborundum extra coarse emery cloth, or its equivalent, so that there is one square inch overlap at one end of the plastic specimens. A pressure of 50 p.s.i. shall be applied over this area for a period of 30 seconds. Load is applied by gripping each end of the test piece in a suitable tensile test machine such as a Dillon or Scott Tester. The average of the load required to break the adhesive bond shall not be less than ten lbs. The speed of testing shall be 0.25 inches per minute. The test shall be conducted at a temperature of 70⁰-80⁰ F.

NOTES

SECTION M-340

MISCELLANEOUS MATERIALS

M-340.01 WATER. Water used in mixing or curing shall be reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable, or other substance injurious to the finished product. Water will be tested in accordance with, and shall meet the suggested requirements of AASHTO T-26. Water known to be potable quality may be used without test. Where the source of water is relatively shallow, the intake shall be so enclosed as to exclude silt, mud, grass, or other foreign materials.

M-340.02 HYDRATED LIME. Hydrated lime, unless otherwise specified shall meet the requirements of paragraph 2 (Chemical composition) and 7.1.1 (Chemical analysis) of ASTM C-6, when tested in accordance with the requirements of ASTM C-25 for Magnesium and Calcium Oxide. Material with a minimum of 90% total calcium and magnesium oxide content may be acceptable if the use of such material, in increased quantity to furnish the equivalent desired total calcium and magnesium oxides, will not result in increased cost over the use of hydrated lime with a minimum content of 95% total calcium and magnesium oxides.

Not more than three percent lime, by weight, shall be retained on a No. 30 sieve and not more than 14 percent, by weight shall be retained on a No. 200 sieve.

The lime shall be protected from exposure to moisture until used and shall be sufficiently dry to flow freely when handled.

M-340.03 HYDRATED LIME FOR ROADBED TREATMENT. These requirements shall conform to the requirements of M-340.02, as stated above.

M-340.04 CALCIUM CHLORIDE. Calcium chloride shall conform to the requirements of AASHTO M-144.

M-340.05 CEMENT GROUT.

(A) Grout shall consist of one part of Portland cement and three parts of sand, thoroughly mixed with water to produce a mortar of a thick cream consistency. Mortar shall be used within thirty minutes after water is added and the mortar shall not be retempered.

(B) Mortar Sand shall conform to article M-100.01 (A) with the exception of the grading which shall conform to the following table:

Passing a No. 4 Sieve	100%
Passing a No. 8 Sieve	90-100%
Passing a No. 16 Sieve	60- 90%
Passing a No. 50 Sieve	15- 40%
Passing a No. 100 Sieve	0- 10%

M-340.06 TOPSOIL MATERIAL.

TABLE OF TOPSOIL GRADATION REQUIREMENTS

Fraction	Particle Size (mm.)	Max. % of Soil (-10 mesh) Fraction
Sand	0.05 - 2.0	85
Silt	0.005 - 0.05	80
Clay	Less than 0.005	50
Gravel	Larger than 2.0	*Max. % of Total Sample

*A maximum of 20% is allowable, however, any quantity greater than 10% will not be included in the basis for payment. The method of test for topsoil gradation is AASHTO T-88.

The soil pH shall be between 5.5 and 8.0, except that the maximum limit may be extended to 8.5 if the exchangeable sodium percentage is less than 10.

The soil shall have a conductivity factor less than 4.

The organic content of the topsoil shall be within a range of values not less than 1% and not greater than 20%.

Topsoil sampling, sample preparation and testing will be done in accordance with procedures outlined by the Montana Test Method MT-412.

M-340.07 MINERAL FILLER.

(1) Material.

Mineral filler shall consist of Portland cement, ground limestone dust, fly ash, or the graded fines free of silt or clay resulting from crushing stone, gravel, or slag or other non-plastic mineral matter. Mineral matter and sources are subject to approval by the engineer. Mineral filler shall meet the following gradation requirements when tested by Montana Test Method MT-301:

Sieves	Total Percent Passing
No. 30	98-100%
No. 80	95-100%
No. 200	65-100%

(2) Mineral filler shall be thoroughly dry and free from lumps of fine particles. Free carbon shall not exceed five percent by weight as measured by the loss on ignition test. The silica content shall not exceed ten percent for uncalcined materials.

(3) AASHTO T-165, 167, and Montana Test Method MT-306 or other tests may be used to determine the need for mineral fillers.

M-340.08 CONCRETE PROTECTIVE COATING.

(A) **Boiled Linseed Oil Mixture.** Boiled linseed oil mixture shall meet the requirements of AASHTO M-233 and shall consist of 50 percent boiled linseed oil and 50 percent petroleum spirits blended by volume. The boiled linseed oil shall meet the requirements of ASTM D-260, Type II. The petroleum spirits commercially known as "Mineral Spirits", shall consist of petroleum distillates only and shall meet the requirements of ASTM D-235.

The protective coat shall be furnished and blended in containers as directed. The non-volatile content of the blended coating shall be based on the specific gravities of the components.

(B) **Water Soluble Liquid Membrane - Forming Compound.** Water soluble liquid membrane - forming compound shall be composed of the following ingredients combined as specified unless otherwise approved in writing by the Engineer prior to manufacture:

<u>Components</u>	<u>Parts</u>
Linseed Oil	600
Fumaric Acid	78
Tri Ethyl Amine	136
Butyl Cellosolve	136
Water	180

Charge Linseed Oil and Fumaric Acid in a closed reactor, mix thoroughly under an inert atmosphere (CO_2 or N_2). Heat to $250\text{--}270^\circ\text{C}$. under constant agitation and hold for clarity in a pill at room temperature (10-15 minutes). This gives an acid number of approximately 60.

Cool to $75\text{--}78^\circ\text{C}$. and add slowly with constant agitation a premix of Tri Ethyl Amine and Butyl Cellosolve.

Add water slowly while still warm with constant agitation.

Next, add driers as follows: (Based on oil solids) 0.02% Mn, and 0.01% Co., water dispersible types.

Typical Range Constants:

1. Viscosity — Between 2-6 strokes at 60% solids depending on length of cook.
2. Weight per gallon. 8.2 pounds
3. Percent Non-Volatile. 60%
4. pH of solution. Typical range 7.5-8.0
5. Viscosity — dilution. Determine on curve.

This formulation meets the applicable requirements of AASHTO M-148 and T-155 for use as a liquid membrane curing compound.

INDEX

	SECTION	PAGE
Abbreviations.....	1.....	1
Act of God.....	7.....	61
Additive, Anti-Stripping.....	30.....	199
Adjust Facilities.....	92.....	509
Aggregate.....	M-100.....	515
Aggregate, Base Course.....	M-100.....	521
Aggregate, Base Course-Crushed Type A.....	M-100.....	521
Aggregate, Bedding for Structures.....	M-100.....	525
Aggregate Concrete.....	40, M-100.....	283, 515
Aggregate, Concrete-Course.....	M-100.....	517
Aggregate, Concrete-Fine.....	M-100.....	515
Aggregate, Cover Material.....	M-100.....	524
Aggregate, Crushed Cover.....	25, M-100.....	191, 524
Aggregate, Disposal of		
Excess Crushed Cover.....	25.....	192
Aggregate, Filter Material.....	M-100.....	525
Aggregate, Fine Concrete.....	M-100.....	515
Aggregate, Gradation for.....	M-100.....	515
Aggregate, Haul.....	12.....	124
Aggregate, Sand Surfacing.....	M-100.....	520
Aggregate, Select Surfacing.....	M-100.....	519
Aggregates, Stockpiling Surfacing.....	26.....	193
Aggregate, Stone Chips.....	M-100.....	524
Aggregate Surfacing.....	20.....	169
Aggregate Surfacing, Binder.....	20.....	170
Aggregate Surfacing -		
Construction-Methods.....	20.....	173
Aggregate Surfacing -		
Control Strip Methods.....	20.....	175
Aggregate Surfacing - Equipment.....	20.....	170
Aggregate Surfacing - Methods		
& Stockpiling.....	20.....	173
Aggregate Surfacing - Surface		
Smoothness.....	20.....	176
Aggregate, Surfacing Stockpiled.....	26.....	193
Aggregate, Top Surfacing, Type A.....	M-100.....	522
Agreement, Supplemental.....	4.....	24
Air-Entrained Concrete.....	40.....	277
Anti-Stripping Additive.....	30.....	199
Artifacts.....	11.....	111
Asbestos Sheets - Corrugated.....	49.....	395
Asphalt, Liquid		
(See Bituminous Materials)		
Assignment - Subletting.....	8.....	65
Automatic Paver Controls, Bituminous		
Plant Mix.....	30.....	207
Automatic Printer System.....	30.....	202
Backfill, Material.....	54.....	419
Barrier, Concrete Median.....	90.....	499
Base, Plant Mix.....	30.....	218
Base, Portland Cement Treated.....	22.....	181
Beads, Glass.....	M-280.....	576
Bearing, Structural Steel.....	43.....	357
Bidding Requirement.....	2.....	11
Bidding Requirements, Combination or		
Conditional Bids.....	2.....	18
Bidding Requirements, Disqualification		
of Bidders.....	2.....	18
Bidding Requirements, Examination		
of Plans, Etc.	2.....	15

INDEX

	SECTION	PAGE
Bidding Requirements, Interpretation of Quantities	2	15
Bidding Requirements, Irregular Proposal	2	16
Bidding Requirements, Material Guaranty	2	19
Bidding Requirements, Prequalification	2	11
Bidding Requirements, Proposal Contents	2	12
Bidding Requirements, Proposal Deliver	2	17
Bidding Requirements, Proposal Guaranty	2	17
Bidding Requirements, Proposal - Issuance of.....	2	12
Bidding Requirements, Proposal, Preparation	2	16
Bidding Requirements, Proposal, Public Opening.....	2	18
Bidding Requirements, Proposal Withdrawal of	2	17
Binder	20	170
Bituminous Materials	M-120	527
Bituminous Materials, Asphalt Cement	M-120	527
Bituminous Materials, Emulsified Asphalt	M-120	527
Bituminous Materials - Medium Curing Cut-Back.....	M-120	527
Bituminous Materials, Rapid Curing Cut-Back.....	M-120	527
Bituminous Materials, Sampling.....	M-120	527
Bituminous Materials, Shipping.....	M-120	528
Bituminous Materials, Slow Curing Cut-Back.....	M-120	527
Bituminous Materials, Testing.....	M-120	528
Bituminous Materials, Temperatures.....	M-120	531
Bituminous Prime Tar Tack Coat	31	223
Bituminous Surface Treatment	32	227
Blankets, Soil Retention	17	156
Blasting	11	107
Blotter Material	31	224
Bolts and Bolted Connections.....	43	348
Bridge, Concrete	41	297
Bridge Railing, Steel.....	48	393
Burning	10	94
Burying, Clearing and Grubbing	10	95
Buy American.....	6	49
Castings.....	M-290	583
Catch Basins	77	451
Cattle Guards.....	82	469
Cement, Portland Cement	40	277
Change Order.....	1, 4	3, 25
Character of Work, Alteration of.....	4	23
Character of Workmen & Equipment	8	68
Chips, Stone	25	191
Chipping, Slash	10	96
Claims for Adjustment and Disputes.....	5	40
Cleanup, Final	4	30
Clearance of Right-of-Way.....	10	91
Clearance of Right-of-Way, Clearing.....	10	91, 93
Clearance of Right-of-Way, Grubbing.....	10	91, 93
Clearance of Right-of-Way, Remove Culverts & Minor Structures.....	10	100
Clearance of Right-of-Way, Remove Pave-Sidewalks.....	10	101
Coating, Protective Concrete Bridge	41	316
Cofferdams	45	370
Commission Furnished Materials	6	49

INDEX

	SECTION	PAGE
Common Carrier Rates, Adjustments		
for Changes in.....	9.....	79
Compaction, Embankment	11.....	112
Compaction, Excavation.....	11.....	106
Compaction, Surfacing	13.....	127
Completion, Calendar Date	1.....	2
Completion, Calendar Day.....	1.....	2
Completion Date, Extension of.....	8.....	70
Completion Date, Failure to		
Complete on Time	8.....	72
Concrete, Air-Entraining	40.....	277
Concrete, Air-Entraining Agents.....	40.....	277
Concrete, Classes of	40.....	277
Concrete, Cold Weather	41.....	305
Concrete Composition.....	39, 40.....	250, 278
Concrete, Consistency	40.....	286
Concrete, Curing	39, 40.....	264, 291
Concrete, Depositing Under Water.....	41.....	303
Concrete, Drainage and Weep Holes	41.....	314
Concrete, Expansion Joints	39.....	266
Concrete, Falsework	41.....	297
Concrete, Finishing.....	39.....	263-264
Concrete, Joint Fillers.....	M-150.....	541
Concrete Placing, in Columns.....	41.....	302
Concrete Placing, in Pavement.....	39.....	254
Concrete Placing, in Slab and		
Girder Space.....	41.....	302
Concrete Placing, In Structures	41.....	299
Concrete, Prestressed	42.....	319
Concrete, Transporting.....	39.....	258
Conduits.....	85, M-310.....	471, 587
Conformity, Reasonably Close	1.....	6
Construction, Contingent Operations	16.....	135
Contingent Construction	16.....	135
Contract, Approval.....	3.....	22
Contract, Assigning or Subletting.....	8.....	65
Contract, Award of.....	3.....	21
Contract, Bond Required	3.....	21
Contract, Default	8.....	73
Contract, Execution & Approval of	3.....	22
Contract, Failure to Execute	3.....	22
Contract, Termination of	8.....	73
Contract Time, Determination of	8.....	70
Contract Time, Extention of	8.....	70
Contractor, Cooperation by.....	5.....	36
Contractor Insurance Involving		
Railroads.....	7.....	60
Contractor, Responsibility for Utilities.....	7.....	62
Contractor, Responsibility for Work.....	7.....	61
Contractor, Termination of Responsibility.....	8.....	74
Control of Work, Authority of Engineer.....	5.....	33, 37
Control of Work, Claims for		
Adjustment	5.....	40
Control of Work, Conformity,		
Plans, Specifications	5.....	33
Control of Work, Cooperation		
Between Contractors	5.....	36
Control of Work, Cooperation		
By Contractor	5.....	35
Control of Work, Cooperation		
With Utilities.....	5.....	35
Control of Work, Coordination, Plans,		
Specifications.....	5.....	34

INDEX

	SECTION	PAGE
Control of Work, Failure to Maintain Roadway	5	39
Control of Work, Inspection of Work	5	38
Control of Work, Plans, Working Drawings	5	33
Control of Work, Removal of Unacceptable Work	5	38
Control Strip, Aggregate Surfacing	20	175
Control Strip, Plant Mix	30	214
Controllers	M-310	593
Coordination of Plans, Etc.	5	34
Cooperation Between Contractors	5	36
Covers	77	451
Covers, Culvert, Cast Iron	77	451
Covers, Risers, Manholes, Etc.	77	451
Cribs and Shoring	45	373
Crushed Base Course	20, M-100	173, 521
Crushed Top Surfacing	20, M-100	173, 522, 523
Culvert, Aluminum Arch	65, M-170	435, 554
Culverts & Cast Iron Pipe	74, M-170	443, 549
Culverts, Arch and Stockpasses	59	429
Culverts, Arch and Stockpasses, Construction Methods	59	430
Culverts, Arch and Stockpasses, Handling and Inspection	59	430
Culverts, Arch and Stockpasses, Materials	59	429
Culverts, Arches, Reinforced Concrete	63, M160	433, 545
Culvert, Backfilling	54	419
Culverts, Bituminous Coated	M-170	550
Culverts, Corrugated Aluminum Arch	65	435
Culverts, Corrugated Steel Pipe	56	425
Culverts, Corrugated Steel Pipe Arch	57, M-170	427, 550
Culverts - Covers, Cast Iron	77	451
Culverts, Elliptical Structural Plate	59	429
Culvert, Excavation	52	411
Culvert, Installation of	54	415
Culverts, Materials	54	415
Culvert, Reinforced Concrete Pipe	62	431
Culvert - Remove and Relay	55	423
Curb Bituminous	75	447
Curb, Integral	39	271
Curbs and Gutters	75	445
Curing, Liquid Membrane	40	293
Damage Claims, Contractor, Insurance Requirements	7	60
Damages Liquidated	8	72
Default of Contract	8	73
Definitions - Terms	1	1
Delineators	88, M-320	489, 652
Density Requirements, Embankment and Excavation	11	115
Detectors and Pushbuttons	M-310	626
Detours, Maintenance of Traffic	4	26
Detours, Special	4	27
Devices, Traffic Guidance	90	497
Disposal of Excess Crushed Cover	25	192
Disposal of Removed Bridge Material	10	100
Disposal of Unsuitable Material	11	111, 115
Drain Tile	M-160	546
Drawings, Working and Plans	5	33
Dryer Drum, Mixing Plant	30	206

INDEX

	SECTION	PAGE
Ducts	85, M-310	471, 587
Dust and Smoke Control	7	59
Dust Control	7	59
Eliminated Items	9	84
Embankment at Structures	11	112
Embankment, Construction	11	111
Embankment, Density Requirements	11	115
Engineer, Authority of	5	33, 37
Equipment Rental	8	66
Equipment, Use of	16	135
Erosion Control	7, 17	55, 141
Excavation, Borrow Excavation	11	103
Excavation, Construction Methods	11	105
Excavation, Culverts	52	411
Excavation, Density Requirements	11	115
Excavation, Ditch	52	411
Excavation for, Rip Rap	52	398
Excavation for, Rubble Masonry	52	401
Excavation, Method of, Measurement	11	116
Excavation, Minor Structures	52	411
Excavation, Rock	11	106
Excavation, Special Borrow	11	104
Excavation, Street Excavation	11	104
Excavation, Structure	45, 52	369, 411
Excavation, Unclassified	11	103
Excavation, Unclassified Channel	11	104
Excess Crushed Cover Material, Payment for	9	87
Excess Moisture, Removal of	11	109
Excess or Unsuitable Material	11	115
Execution & Approval of Contract	3	22
Expansion Joints at Structures	39	268
Explosives, Use of	7	54
Extra Work	4, 9	25, 82
Facilities, Adjust, Remove & Reset	92	509
Failure to Complete On Time	8	72
Failure to Execute Contract	3	22
Failure to Maintain, Roadway or Structure	5	39
Federal Aid Provisions	7	52
Fence	81	461
Fence, Chain Link, Aluminum	80, M-210	455, 555
Fence: Chain Link Steel	80, M-210	455, 555
Fence, Construction Methods	81	461
Fence, Materials	81, M-210	461, 558
Fence, Removal Temporary	81	466
Fence, Remove and Reset	81	464
Fertilizer	17	143
Field Laboratories	6	48
Filter Material, Structures	M-100	525
Final Inspection	5	39
Final Payment	9	85
Fires, Responsibility for	7	59
Flagmen and Flagging	4	29
Flume - Metal and Wood	73	439
Force Account Work	9	82
Forms and Falsework Removal	41, 43	307, 358
Foundation Course	39	250
Foundation Materials	45	370
Freight Rates	9	79
Glass Beads	M-280	576
Grades, Construction Staking	5	36
Gravel (See Aggregates)		
Gravel Pits, Clean Up	4	30

INDEX

	SECTION	PAGE
Grout, Cement	M-340	661
Grubbing	10	91, 93
Guaranty, Material	2	19
Guaranty, Proposal	2	17
Guaranty, Return of Proposal	3	21
Guard Rail, Aluminum	90	497
Guard Rail, Aluminum Beam	M-220	565
Guard Rail, Metal Beam	90	497
Guard Rail, Posts	M-220	565
Guard Rail, Steel Beams	M-220	565
Guards - Cattle	82	469
Guidance Devices, Traffic	90	497
Guide Posts, Concrete	M-220	567
Guide Posts, Wood	M-220	567
Guide Posts, Steel	M-220	567
Gutter and Curbs	75	445
Haul	12	123
Haul, Aggregate	12	124
Headwalls, Concrete	73	439
Highway, Opening to Traffic	7	61
Hydrated Lime, Chemical Additive	30	199
Imperfect Trench Method	54	420
Incising, Treated Timber	M-270	570
Inlets	77	451
Inspection, Final	5	39
Inspection of Work	5	38
Inspection, Plant	6	47
Inspectors, Authority and Duty of	5	37
Installation of Pipe Culverts	54	415
Insurance Involving Railroads, Contr.	7	60
Insurance Requirements - Contractor	7	60
Irrigation Facilities	73	439
Irrigation Water, Maintenance of	4	30
Joint Abutting, Structural Steel	43	343
Joint, Concrete Pavement	39	266
Joint, Bridge Approach Slab	41	304
Joint, Materials	M-150	541
Laboratory, Field	6	48
Laboratory, Helena	1	5
Laws To Be Observed	7	51
Legal Relations and Responsibility To Public	7	51
Legal Right, No Waiver of	7	64
Liability of Public Officials	7	64
Licenses, Permits and Taxes	7	51
Lighting and Signal Materials	M-310	585
Lime, Hydrated	18, M-340	159, 661
Lime, Treated Roadbed	18	159
Limitation of Operations	8	68
Lines, Construction Staking	5	36
Lining, Ditch, Metal and Wood	73	439
Linseed Oil, Boiled	41	317
Liquidated Damages	8	72
Load Restrictions	7	54
Local Material Sources	6	41
Maintenance, Roadway During Construction	4, 5	30, 39
Maintenance, Special	4	26
Maintenance, Traffic During Suspensions of Work	4	27
Mahholes	77	451
Markers and Monuments	96	511
Markers, Project	96	511

INDEX

	SECTION	PAGE
Markers - Station	96.....	511
Markings and Markers, Pavement	89.....	491
Markings, Removal of Pavement	89.....	495
Materials, American Made	6.....	49
Materials, Bituminous	M-120	527
Materials, Commission Furnished	6.....	49
Materials, Contractor Furnished Source	6.....	42
Materials, Control of	6.....	41
Material, Department Optioned Sources	6.....	41
Materials, Fencing	M-210	555
Materials, Found on Work	4.....	31
Materials, Guaranty	2.....	19
Materials Handling	6.....	48
Material, Indicated Sources	6.....	41
Materials, Joint	M-150	541
Materials, Lighting and Signal	M-310	585
Material, Local Sources	6.....	41
Materials, Mandatory Sources	6.....	43
Material, Quality Requirements	6.....	41
Materials, Signing	M-320	639
Material, Source of Supply	6.....	41
Materials, Storage of	6.....	48
Materials Unacceptable	6.....	48
Materials, Unsuitable	11.....	115
Measurement, Quantities	9.....	77
Members, Prestressed Concrete	42.....	319
Median Barrier, Concrete	90.....	499
Mesh, Wire	47.....	389
Metal Beam Guard Rail	90.....	497
Metal Pipe	M-170	549
Mineral Filler	30, M-340	199, 662
Mixing, Concrete Pavement	39, 40	256, 287
Mixing, Concrete at Site	40.....	287
Mixing - Concrete Central Plant	40.....	289
Mixing, Concrete Ready Mix	40.....	288
Mixing - Concrete Truck	40.....	289
Mobilization	9.....	88
Modification, Roadbed	19.....	163
Monuments and Markers	96.....	511
Monuments - Right-of-Way	96.....	511
Mortar, Slope Protection	50.....	405
Mulch	17.....	148, 149
Non-Participating Items	97.....	513
Notice to Proceed	8.....	66
Obliterate Roadway	16.....	138
Opening to Traffic	7.....	61
Operations, Limitation of	8.....	68
Paints and Painting	91, M-280	501, 571
Paints and Painting, Steel-Shop and Field	43, 91	356, 503
Paints and Painting, Traffic Lines	89.....	493
Paints and Painting, Wood Rail and Post	91.....	507
Partial Payments	9.....	84
Pavement, Concrete Finishing	39.....	254
Pavement Markings and Markers	89.....	491
Pavements, Plant Mix	30.....	195
Pavement, Portland Cement - Concrete	39.....	249
Pavements, Road Mix Bituminous	33.....	235
Paver, Slip Form	39.....	259
Paver Controls, Plant Mix	30.....	207
Payment, Advance for Materials	9.....	85
Payment and Measurement	9.....	77

INDEX

	SECTION	PAGE
Payment, Final and Acceptance	9	85
Payment for Extra Work.....	9	82
Payments, Partial.....	9	84
Payments, Scope of.....	9	79
Permits, Licenses, and Taxes.....	7	51
Permit, Surfaces Opened By.....	7	52
Piling.....	46	375
Piling, Concrete	46	376
Piling, Construction Methods.....	46	380
Piling, Driving.....	46	377
Piling, Furnish.....	46	376
Piling, Inspection	46	379
Piling, Load Tests	46	376
Piling, Materials-Types	46	375
Piling, Test	46	376
Piling, Treated.....	46	375
Piling, Untreated	46	375
Pipe Arch Culvert, Materials.....	57, 65, M-170	427, 435, 550
Pipe, Asbestos - Cement	M-160	547
Pipe, Clay	M-160	546
Pipe, Clay Crade Invert.....	M-160	547
Pipe - Concrete, Clay, Fiber and Plastic	M-160	545
Pipe, Concrete Pressure.....	M-160	546
Pipes, Conduits and Ducts		
(Encased in Concrete).....	41	314
Pipe, Copper	M-170	554
Pipe, Corrugated Aluminum.....	M-170	554
Pipe, Drain Tile	M-160	546
Pipe, Perforated, Bituminized Fiber	M-160	547
Pipe, Perforated Concrete.....	M-160	546
Pipe, Porous Concrete.....	M-160	546
Pipe, R.C.P. Clay Lined	M-160	546
Pipe, Reinforced Concrete.....	M-160	545
Pipe, Slotted - Corrugated Steel	M-170	554
Pipe, Steel - Seamless	M-170	554
Pipe, Tubing	78, M-170	453, 554
Pipe, Underdrains.....	69, M-160, M-170	437, 546, 553
Pipe, Underdrains Corrugated Steel.....	M-170	553
Pipe, Vitrified Clay	M-160	547
Pipe, Wrought Iron.....	78	453
Plank, Asphalt	49	395
Plans, Alteration of.....	4	23
Plans, Conformity with.....	5	33
Plans, Examination of.....	2	15
Plans, Working Drawings.....	5	33
Plant Inspection.....	6	47
Plant Mix Pavement	30	195
Plant Mix Base, Placing		
& Compacting	30	220
Plant Mix, Cold Feed Control	30	198
Plant Mix, Compaction.....	30	213
Plant Mix, Construction Methods	30	211
Plant Mix - Dryer Drum.....	30	206
Plant Mix, Gradations	30	196
Plant Mix, Aggregate	30	196
Plant Mix, Bituminous Material	30	198
Plant Mix, Mineral-Filler	30	199
Plant Mix, Plants	30	203, 205, 206
Plant Mix, Preparation Aggregate.....	30	208
Plant Mix, Preparation Bituminous		
Mixture.....	30	210
Plant Mix, Roadway Equipment.....	30	206
Plant Mix, Scales	30	202

INDEX

	SECTION	PAGE
Plant Mix, Surface Tolerances.....	30.....	216
Poles, Barn.....	M-320.....	643
Poles and posts.....	M-270.....	569
Poles and Posts, Treated Timber.....	M-320.....	642
Portland Cement, Concrete.....	40.....	277
Portland Cement, Treated Base.....	22.....	181
Post - Poles, Chain-Link Fence.....	80, M-210.....	455, 555
Posts - Poles, Guard Rail and Guide.....	90, M-220.....	498, 566
Posts - Poles, Sign.....	88, M-320.....	489, 641
Posts - Poles, Wire Fence.....	81, M-210.....	461, 558
Preparation - Roadbed Surface.....	19.....	165
Prequalification of Bidders.....	2.....	11
Presplitting Rock Backslopes.....	11.....	106
Prestressed Concrete.....	42.....	319
Prestressed Concrete, Construction.....	42.....	322
Prestressed Concrete, Fabrication-Drawings.....	42.....	319
Prestressed Concrete, Materials.....	42.....	320
Prewetting Excavation Areas.....	13.....	129
Prime Coat, Bituminous.....	31.....	223
Prime, Construction.....	31.....	224
Prime, Equipment.....	31.....	223
Prime, Materials.....	31.....	223
Prime, Protect-Traffic.....	31.....	225
Prime, Weather Limitations.....	31.....	223
Printer System, Automatic.....	30.....	202
Proceed, Notice.....	8.....	66
Proposal, Consideration of.....	3.....	21
Proposal, Form.....	2.....	12
Proposals, Irregular.....	2.....	16
Proposal, Issuance of.....	2.....	12
Prosecution and Progress.....	8.....	65
Prosecution of Work.....	8.....	66
Protection, Bank and Slope.....	50.....	397
Protection - Traffic Structures.....	32, 33.....	232, 237
Protection, Forest.....	7.....	59
Public Convenience and Safety.....	7.....	53
Pull Boxes.....	85, M-310.....	471, 588
Quality and Source of Supply.....	6.....	41
Quantities, Altered Compensation for.....	9.....	82
Quantities, Measurement of.....	9.....	77
Railing, Median Barrier.....	90, M220.....	498, 565
Railing, Steel Bridge.....	48, M290.....	393, 581
Railway Highway Provisions.....	7.....	53
Reclamation Requirements.....	6.....	43
Reflective Sheeting A.....	M320.....	644
Reflective Sheeting B.....	M320.....	648
Reflectorized Pavement Markers.....	M320.....	657
Reflectors, Acrylic.....	M320.....	651
Reinforcing Steel.....	47.....	389
Reinforcing Steel, Bar Reinforcement.....	M290.....	581
Reinforcing Steel, Fabrication.....	47.....	389
Reinforcing Steel Material.....	47.....	389
Reinforcing Steel, PlacingSplicing.....	47.....	390
Remove and Relay Pipe Culverts.....	55.....	423
Remove, Major Structures.....	10.....	99
Remove, Reset, Adjust Facilities.....	92.....	509
Responsibility for Utilities, Contractor.....	7.....	62
Responsibility for Work, Contractor.....	7.....	61
Restoration of Property.....	7.....	55
Restoration of Surface.....	7.....	52
Restrictions, Load.....	7.....	54
Retaining Walls.....	51.....	407
Right of Way, Clearance.....	10.....	91

INDEX

	SECTION	PAGE
Right of Way, Clearing	10	91, 93
Right of Way, Furnishing	7	63
Right of Way, Grubbing	10	91, 93
Right of Way, Remove Culverts & Minor Structures	10	100
Right of Way, Remove Pavement-Sidewalks	10	101
Rights of Materials Found	4	31
Rip Rap, Cement Rubble Masonry	50	402
Rip Rap, Dry Rubble Masonry	50	402
Rip Rap, Grouted	50	399
Rip Rap, Hand Laid	50	398
Rip Rap, Random	50	397
Rip Rap, Sacked Concrete	50	400
Risers	77	451
RivetsRiveting, Field	43	347
RivetsRiveting, Shop	43	347
Road Leveler Operations	16	137
Road Mix Bituminous Surfacing	33	235
Roadbed Modification	19	163
Roadside Development	17	141
Rolling and Watering	13	125
Rolling, Charts	13	131, 132
Rolling, Equipment	13	125
Rolling, Roadbed Compaction	13	127
Rolling, Surfacing Courses	13	127
Safety, Public	7	53
Samples Tests	6, 20	46, 169
Sand, Mortar	M-100	516
Sanitary Provisions	7	52
Scale, Aggregate Surfacing	20	171
Scales, Plant Mix Pavement	30	202
Scope of Work	4	23
Seal Coat	34	243
Sealers, Culvert	M-150	541
Seed-Seeding	17	142
Seeding, Dates	17	147
Sewers, Concrete Pipe	62	431
Sheets, AsbestosCorrugated	49	395
Shoring & Cribb	45	373
Sidewalks, Concrete	76	449
Sidewalks, Finish	41	309
Signals, Traffic	87, M-310	477, 585
Signing Materials	M-310	585
Signs, Aluminum	88, M-320	489, 640
Signs and Signing	88, M-320	487, 639
Signs, Traffic Control	4	28
Signs, Warning and Detour	4	26
Situation, Control	7	55
Slope and Bank Protection	50	397
Slope and Bank Protection, Construction Methods	50	398
Slope and Bank Protection, Rip RapGrouted	50	399
Slope and Bank Protection, Rip RapHand Laid	50	398
Slope and Bank Protection Rip RapRandom	50	398
Slope and Bank Protection, Rip RapSacked Concrete	50	400
Slope and Bank Protection, Rubble Masonry	50	401
Slope Protection	50	397
Sloping, Excavation and Embankment	11	109

INDEX

	SECTION	PAGE
Smoke and Dust Control	7	59
Smoothness, Existing Surface Preparation	19	165
Smoothness, Surface	20	176
Smoothness, Surface Base Course	20	173
Smoothness, Surface Plant Mix	30	211
Sodding	17	153
Sources of Materials, Contractor		
Furnished	6	42
Source of Materials, Indicated Sources	6	41
Sources of Materials, Mandatory	6	43
Source of Supply and Quality	6	41
Specifications, Coordination of, Etc.	5	34
Stakes Construction	5	36
Stockpiled Surfacing Aggregates	26	193
Stockpiles, Mobilization State Maintenance	9	89
Stone Chips	25	191
Storage of Materials	6, 43	48, 342
Straightedging, Concrete Structures	41	310
Straightedging, Plant Mix Base	30	220
Straightedging, Plant Mix	30	216
Structural Plate Pipe,		
Arch Culverts	59	429
Structural Plate Elliptical Culverts	59	429
Structural Plate, Stockpasses	59	430
Structural Steel	M-290	581
Structural Steel, Assembling Shop	43	354
Structural Steel, Bearing and Achorage	43	357
Structural Steel, Bearing Surfaces	43	343
Structural Steel, Bolts	43	348
Structural Steel, Construction	43	356
Structural Steel, Drilled or		
Reamed Holes	43	346
Structural Steel, Fabrication	43	342
Structural Steel, Field	43	355
Structural Steel, Marking and Shipping	43	356
Structural Steel, Materials	43, M-290	341, 581
Structural Steel, Mill and		
Shop Inspection	43	342
Structural Steel, Painting	43	356
Structural Steel, Pilot and		
Driving Nuts	43	345
Structural Steel Pins	43	345
Structural Steel, Punching	43	346
Structural Steel, Reaming	43	346
Structural Steel, Rivets and Riveting	43	347
Structural Steel, Shop Drawing	43	341
Structural Steel, Storage	43	342
Structural Steel, Straightening	43	358
Structural Steel, Web Plates	43	344
Structural Steel, Welding	43	354
Structural Steel, Workmanship and Finish	43	343
Structure Excavation	45, 52	369, 411
Structure Items, Miscellaneous	49	395
Structures, Bedding Material	M-100	525
Structures, Concrete	41	297
Structures, Concrete Arches & Pipe	63, M-160	433, 545
Structures, Concrete	41	297
Structures, Prestressed Concrete Member	42	319
Structures, Remove	10	98
Structures, Steel	43	341
Structures, Timber, Deck		
Waterproofing	44	365
Structures, Timber, Hardware	44	363

INDEX

	SECTION	PAGE
Structures, Timber, Material	44.....	363
Structures, Timber, Painting	44, 91.....	367, 507
Subletting - Assignments	8.....	65
Subletting of Contract	8.....	65
Supplemental Agreement	4.....	24
Supplemental Specifications	1.....	8
Surface Preparation, Existing	19.....	165
Surface, Restoration of	7.....	52
Surface Treatment Bituminous Construction	32.....	229
Surface Treatment, Bituminous Equipment	32.....	223
Surface Treatment, Bituminous Materials	32.....	223
Surface Treatment, Bituminous Protect Traffic	32.....	225
Surfacing, Bituminous Surface Treatment	32.....	227
Surfacing, Contractor Furnished	6.....	42
Surfacing, Crushed Base	20, M100.....	173, 521
Surfacing, Crushed Cover	25.....	191
Surfacing, Crushed Top	20, M100.....	173, 522, 523
Surfacing, Plant Mix Bituminous	30.....	195
Surfacing, Road Mix Bituminous	33.....	235
Surfacing, Sand	21.....	179
Surfacing, Seal Coat	34.....	243
Surfacing, Selected	21.....	179
Surfacing Types, Various	21.....	179
Syphons, Pipe	54.....	417
Tack Coat, Bituminous	31.....	223
Tack Coat, Construction	31.....	224
Tack Coat, Equipment	31.....	223
Tack Coat, Materials	31.....	223
Tack Coat, Protect Traffic	31.....	225
Tack Coat, Weather Limitations	31.....	223
Tax, Fuel	7.....	51
Taxes, Licenses and Permits	7.....	51
Tension, Bolts	43.....	351
Termination of Contract	8.....	73
Tests and Samples	6, 20.....	46, 169
Timber Structures	44.....	363
Timber, Treated and Untreated	M-220.....	569
Timber, Treatment, Incising	M-270.....	569
Time, Failure to Complete on	8.....	72
Topsoil	17, M-340.....	141, 662
Topsoil, Salvaging and Placing	11.....	115
Traffic Guidances Devices	90, M-220.....	497, 565
Traffic Control, Provisions for	4.....	28
Traffic, Opening Sections of Project	7.....	61
Traffic, Provisions for Traffic Control	4.....	28
Traffic Signals and Appurtenances	M-310.....	622
Traffic Signals and Lighting	87.....	477
Traffic Signals and Lighting, Conductors and Wiring	87.....	480
Traffic Signals and Lighting, Equipment List and Drawings	87.....	477
Traffic Signals and Lighting, Painting	87.....	483
Traffic Signals and Lighting, Regulations and Code	87, M-310.....	477, 587
Traffic Signals and Lighting, Wiring Diagrams	87.....	478
Tubing and Pipe	78, M-170.....	453, 554
Unacceptable and Unauthorized Work	5.....	38
Underdrains	69.....	437
Underpasses, Reinforced Concrete Arches	63.....	433
Utilities, Cooperation with	5.....	35
Walls - Retaining	51.....	407

INDEX

	SECTION	PAGE
Watering.....	13, M-340	128, 661
Water for Concrete.....	40.....	283
Water Pollution.....	7.....	55
Waterproofing, Timber Bridge Deck.....	44.....	365
Water Stops, Copper.....	M-150	542
Water Stops, Plastic.....	M-150	543
Water Stops, Rubber	M-150	542
Weights, Rollers.....	13.....	125
Weights, Scale.....	20.....	171
Weep Holes	41.....	314
Welding Electrodes	M-290	581
Welds and Welding.....	43.....	354
Wire Mesh	M-290	581
Work, Prosecution of.....	8.....	66
Work, Scope of	4.....	23
Work, Suspension of	8.....	70
Workmen and Equipment, Character of.....	8.....	68

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